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ADA031770

Life Cycle Cost Task Group

of the
Joint Services
Data Exchange
FOR INERTIAL SYSTEMS

Proceedings of Quarterly Meeting

25-27 February 1975
at
St. Petersburg, Florida

LIFE CYCLE COST TASK GROUP

OF THE

JOINT SERVICES DATA EXCHANGE FOR

INERTIAL SYSTEMS

PROCEEDINGS OF QUARTERLY MEETING

25 FEBRUARY 1975

AT

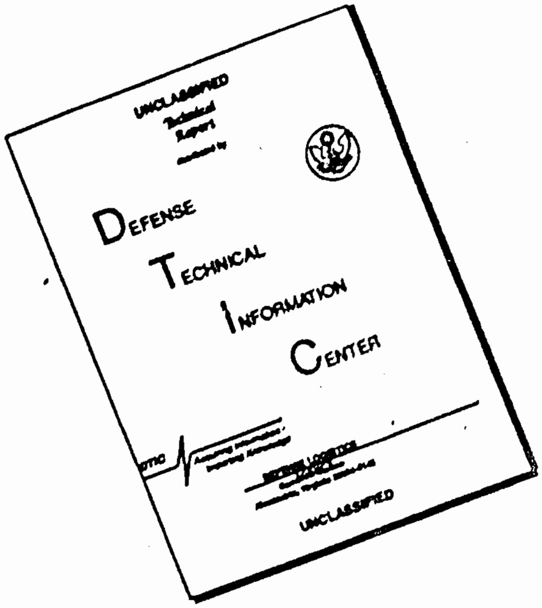
ST. PETERSBURG BEACH, FLORIDA

Compiled and Edited

by

Russell B. Stauffer

DISCLAIMER NOTICE



ABSTRACT

These proceedings describe the activities of the sixth quarterly meeting of the Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems held 25-27 February 1975.

The proceedings contain the text and slides (where available) of the invited papers and the results of sub-group meetings on creation of an LCC Task Group descriptive paper, preparation of input/output specifications and finalization of variable names for the LCC model under development.

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AGENDA

QUARTERLY MEETING
LIFE CYCLE COST TASK GROUP
OF
THE JOINT SERVICES DATA EXCHANGE

TUESDAY, FEBRUARY 25, 1975

Registration and Coffee	9:00 - 9:30	
Introductory Remarks	9:30 - 9:35	R. Stauffer, DRC
Working Group Problems & Task Assignments	9:35 - 10:30	Keith Gibson, Autonetics
Working Group Activities	10:30 - 12:00	
Lunch	12:00 - 1:00	
Working Group Activities	1:00 - 4:30	

WEDNESDAY, FEBRUARY 26, 1975 - "INVITED PAPERS"

Welcome	9:00 - 9:15	"Honeywell"
"Air Force Reliability Improvement Warranties"	9:15 - 10:00	R. Adel, Northrup
Coffee Break	10:00 - 10:15	
"Economic Model of a Repair Depot"	10:15 - 11:00	Ted Crosier, AGMC
"Base Maintenance & Supply"	11:00 - 12:00	Col. H. Brewer)MacDill Lt. Col. J. Turner) AFB
Lunch	12:00 - 1:00	
"Repair Reliability Based on Total Cost Considerations"	1:00 - 1:45	R. Stauffer, DRC
"Closing the Loop on Life"	1:45 - 2:30	F. Merlino, Northrup
Coffee Break	2:30 - 2:45	
Working Activities	2:45 - 4:30	

THURSDAY, FEBRUARY 27, 1975

Working Group Activities	9:00 - 11:00	
Reports of Working Groups	11:00 - 12:00	
Lunch	12:00 - 1:00	
Executive Board Meeting	1:00	

PROCEEDINGS
OF THE
LIFE CYCLE COST TASK GROUP

FEBRUARY 25-27, 1975
ST. PETERSBURG BEACH, FLORIDA

1. INTRODUCTION

The winter meeting of the Life Cycle Cost Task Group of the Joint Services Data Exchange was called to order by the Chairman, Mr. Russell Stauffer, at 9:30 a.m. on February 25, 1975. After opening remarks by Mr. Stauffer, the meeting was turned over to Keith Gibson of Autonetics to establish the activities of the working groups for the winter meeting.

Mr. Gibson divided his remarks into two parts. (See Figures 1-3). The first was a review of the results of the last meeting, and the second discussed the requirements for the present meeting. Basically, his concern in the present meeting was to promote the free interchange of ideas on four topics.

a) Input/Output Techniques
b) Model Contents
c) Deployment Definition
d) Detail Level

LCC Model Development/Implementation Schedule

LCC Task Group – Joint Services Data Exchange

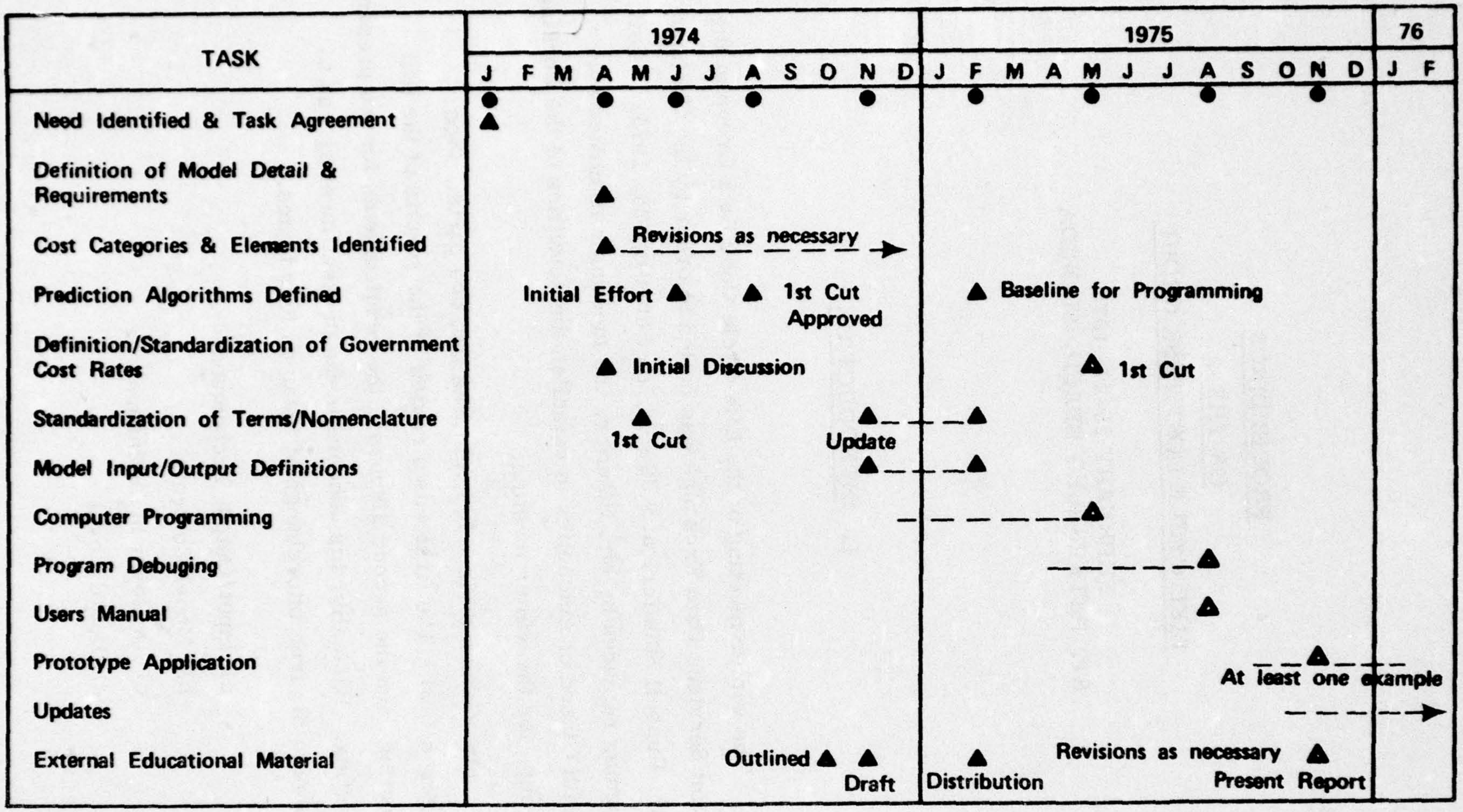


Figure 1

MODEL PROGRAMMING – HERE IS WHERE WE ARE GOING

TERMS CONSOLIDATED/STANDARDIZED

OUTPUT REQUIREMENTS AND FORMATS DETAILED* — COLCORD, TAYLOR

INPUT DATA CONTENT, DETAIL, AND FORMAT DEFINED* — RODRIGUEZ, LAIRD DeBURKARTE, HANKS

COMPUTER RESTRICTIONS IDENTIFIED

FLOW CHARTS AND OTHER PROGRAMMER DATA DEVELOPED ← Calculation Sequence, Algorithm Consolidation, Final Flow Charts

"FINAL" ALGORITHM REVISIONS AGREED UPON
PROGRAM MECHANIZATION (PROGRAMMING) COMPLETED ← Questions, Questions, Content Mechanization, Correctness

USERS MANUAL PREPARED

GOVERNMENT (USER) COST RATES ESTABLISHED

FIRST CUT RDT&E CONSTANTS SELECTED

TEST APPLICATIONS MADE

*TASKS OF NOVEMBER WORKING GROUP
← TASKS OF FEBRUARY WORKING GROUP

Figure 2

SESSION OBJECTIVE??

Provide a MAXIMUM INTERCHANGE of IDEAS and Model definition.

ID Techniques
Model Content
Deployment Definition
Detail Level

Whatever the result — I will attempt to provide a FORTRAN program of it by our next meeting.

Figure 3

Mr. Gibson suggested that if these topics could be satisfactorily resolved at this meeting that it would be possible then for him to proceed to write the FORTRAN algorithms necessary to program the model.

The meeting was then turned over to Mr. William Colcord of Lear Siegler who, at the Redondo Beach meeting, had taken responsibility for defining the outputs of the model. Among the questions that were raised during Mr. Colcord's presentation were whether it should be possible within the Life Cycle Cost model to give an annual cost breakdown for budgetary purposes.

In addition to a review of the output formats suggested at the Redondo Beach meeting and subsequently finalized by Mr. Colcord, several other topics came up for discussion (See Section 2.1.) The first of these was the question of the model use in accordance with the phase of the program. As can be seen from Figure 2-1 the question resolved around where it would be possible to use Cost Estimating Relationships (CER) and where the model itself might be of value. A second question had to do with the work breakdown structure which Mr. Colcord had developed for all three phases of the model. It was felt that there should be a definite relationship between this work breakdown structure and the inputs and outputs of the model. Three specific questions arose from his presentation.

1. Where is the cost of AGE development.
2. In the acquisition submodel there appears to be no cost for engineering data for test equipment and AGE.
3. In the O&M Sub-model there is no provision for augmented supported costs.

As a result of Mr. Colcord's presentation there was considerable discussion on the relationships between ORLA or LOR and LCC. This was finally resolved in terms of the diagram in Figure 4. An ORLA (or LOR) has an inherent cost but may well be selected on the basis of cost. Basically, the two are independent although related; one does not supersede the other.

Bob Rodriguez of Litton then reported on the progress made with the data inputs. The list of inputs is presented in Section 2.2. Effectively what has been accomplished has been to check the input list for redundancy. This is complete for the RDT&E phase and Bob plans to continue the work with the acquisition and O&M phases during this meeting. He has also taken the responsibility for providing the indenture levels which permit the use of data override in the model.

Don DeBurkarte of Collins Radio had done considerable work on developing input techniques for the model. His presentation material is found in Section 2.3. Details of his recommendations are in Appendix "A". His basic recommendation is that all inputs be an 80 column punch card format and that cards be arranged in series so that related items can be readily identified.

On the basis of the questions raised during these presentations, four working parties were organized and met during the balance of the day, on Wednesday afternoon and part of Thursday morning.

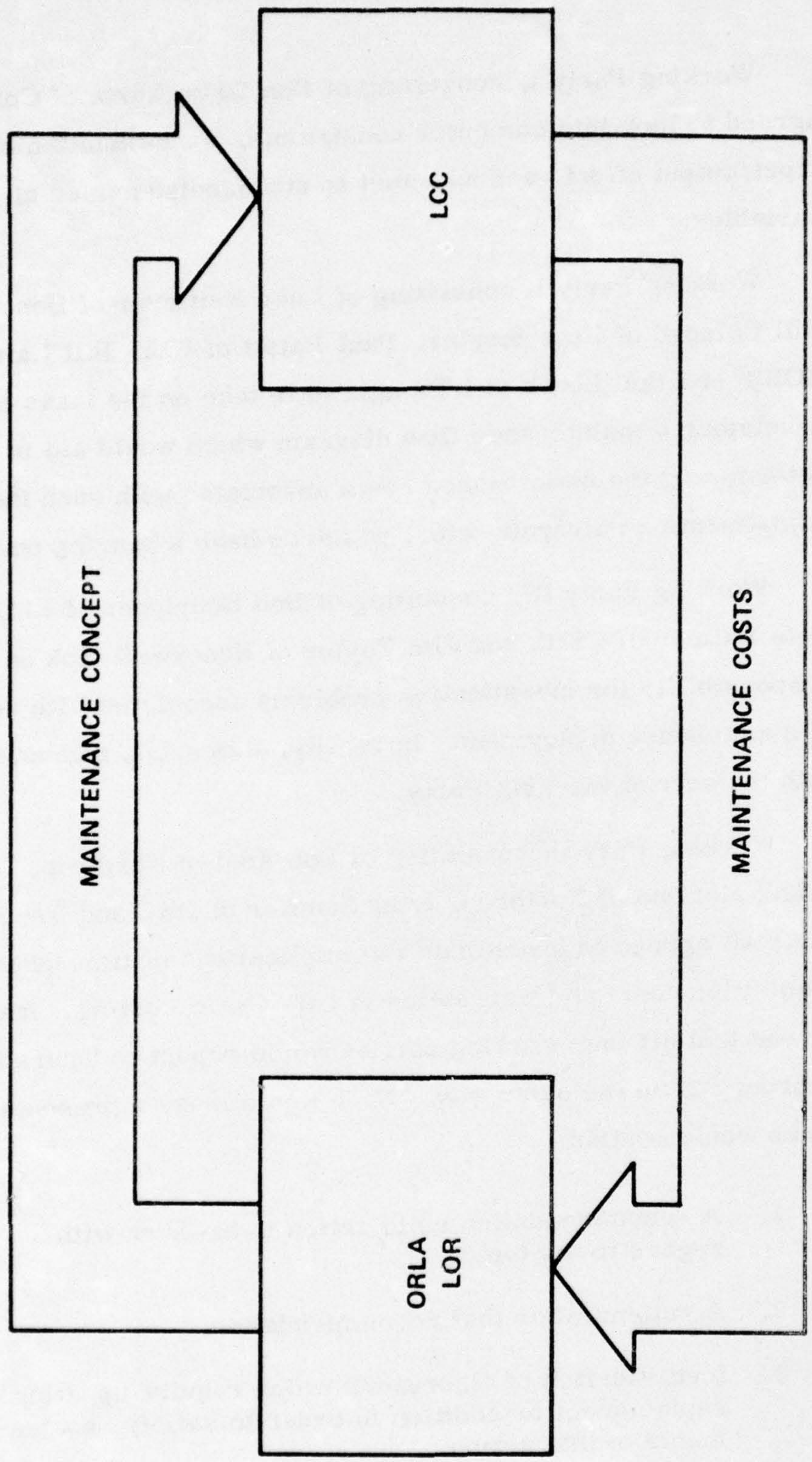


Figure 4

Working Party I, consisting of Don DeBurkarte of Collins agreed to look into computer constraints, a continuation of the input/output effort, and an effort to standardize names of variables.

Working Party II consisting of Luke Reitmyer of Honeywell, Bill Colcord of Lear Siegler, Paul Palatt of IDA, Bill Laird of NORIS and Bob Beech of LTV agreed to take on the tasks of developing a maintenance flow diagram which would aid in determining the maintenance costs associated with such items as adjustments on aircraft, etc., which do have a bearing on costs.

Working Party III, consisting of Bob Rodriguez of Litton, Pete Palmer of CSDL and Jim Taylor of Honeywell took on responsibility for investigating problems associated with details of maintenance deployment. In reality, this group combined forces with the second Working Party.

Working Pary IV consisting of Bob Adel of Northrop, Frank Merlino of Northrop, Russ Stauffer of DRC and Freda Kurtz of AFAL agreed to investigate the implications of time-phased acquisition costs and warranties in Life Cycle Costing. It was agreed that all four working parties would report on Thursday, February 27 in the same way. Each would make a presentation which would contain:

1. A recommendation as to action to be taken with regard to the topic.

2. A rationale for that recommendation.

3. Identification of algorithms which require updating, replacement or addition in order to satisfy requirements of that action.

Wednesday, February 26th was devoted to presentations of invited papers. The opening speaker was Mr. Ray Hoopes, Director of Product Support for the Honeywell Aerospace Group in St. Petersburg. In his opening welcome, Mr. Hoopes stressed the value that he found in competitors working together to solve a common problem. He also commented that the lack of government personnel who were able to be present was as much a sign of the times as of disinterest but felt that every effort should be made on the part of the group to see to it that their participation could be possible. He also felt he would like to see the Life Cycle Cost Group complete their work so that it could be tested in the main stream of the inertial systems community.

The second speaker was Mr. Robert Adel of Northrop Electronics Division, who spoke on Reliability Improvement Warranties. The text and illustrations from Mr. Adel's paper are contained in Section 4.1.

The third speaker was Mr. Russell Stauffer of Dynamics Research Corporation who presented a paper entitled "Repair Reliability Based on Total Cost Considerations". This paper and its illustrations are found in Section 4.2.

The final speakers of the morning were Col. Harry Brewer, Deputy Commander from Maintenance and Lt. Col. James Turner, Chief of Supply at MacDill Air Force Base. These gentlemen discussed the relationships between base maintenance and supply and generally described the flow of material as it passes through the repair cycle at the organizational and intermediate maintenance levels. Although both Col. Brewer and Col. Turner stressed the

fact that MacDill is a training base and consequently has requirements somewhat different from the normal TAC base they still felt that what they were presenting was reasonably typical. Overall some 2,000 items are repaired each month at MacDill. The supply system contains an inventory of 11 million dollars and does approximately 7.8 million dollars in local business annually. Some 58 million dollars is involved in equipment and 305 people are employed in the supply system. Illustrations from their paper are found in Section 4.3.

The final invited speaker of the day was Mr. Frank Merlino of Northrop Electronics who continued a paper which he had initially presented at the November meeting at Redondo Beach. This paper was entitled "Closing the Loop on Life Cycle Cost". The slides which Mr. Merlino used are found in Section 4.4.

Mr. Ted Crosier of AGMC who had been scheduled to speak on "Economic Model of the Repair Depot" was unable to attend the meeting so his paper was eliminated.

Following the presentation of the formal papers, Mrs. Freda Kurtz of the Air Force Avionics Laboratory, requested time to present a problem with which she was currently faced. She has been asked to create a cost estimating relationship model for the acquisition phase of a new inertial system. She has previously sent, to most of the members of the Task Group and to other persons in the industry, a set of equations which were a first cut of such a model. She was requesting support and assistance in critiquing of the existing equations and in suggestions as to how information,

which would enable her to calculate some of the ratioing factors, might be obtained. Mrs. Kurtz's personal comments on the problem are found in Section 4.5.

The morning of Thursday, February 27th was devoted to reports from the individual working parties which had been formed on Tuesday. In continuation of the reports of the Redondo Beach Working Groups Bob Adel of Northrop presented the paper developed at Redondo Beach. The text of the paper appears in the November proceedings of this organization. Section 2.4 contains the visuals designed to be used with that presentation. Bob announced that within limits he was prepared to create viewgraphs for individuals intending to use this material. Such viewgraphs would eliminate the Northrop logo in the lower right-hand corner and substitute somewhere on the page the official emblem of the Life Cycle Cost Task Group.

Don DeBurkarte of Collins Radio reported for Working Party I. His recommendations with regard to I/O efforts were that activities already underway be continued and along the same lines, the problem was to avoid getting bound up in details of terminologies to the detriment of programming startup. His comments are presented in Section 3.1. He also recommended that with respect to variable names that the list shown be utilized, additions will be incorporated as they arise. With regard to computer constraints the third area of concern, Don recommends that each interested party who anticipates the possibility of using the Life Cycle Cost Model forward to Keith Gibson of Autonetics, the following information.

1. Description of the hardware which they will be using.

2. The availability of core storage.

3. A description of the mass storage available.

4. Identification of the operational software under which the Life Cycle Cost Model must operate.

Working Group II under the direction of Bill Colcord had created the maintenance action flow included in Section 3.2. Although not directly related to the model it served to clarify where times can be calculated as being significant in the total cost of the system. As a result of this presentation the question was also raised as to whether a fourth level of repair, i.e., a vendor depot in addition to a government depot, needed to be considered as a potential cost element. The consensus was that the fourth level could be incorporated without making major changes to the algorithms of the O&M submodels.

Working Party III under direction of Rod Rodriguez had worked closely with Working Party II so that the maintenance concept and deployment factors were considered under all cases. After some discussion as to whether the models would support the concept where a single base supported multiple sites, the decision was reached that we are concerned about a cost model and not truly a simulation of the maintenance and supply system. Therefore, it was felt that the model as it existed could accomodate these conditions.

Working Party IV had considered two major topics.

1. Cost Time-Phasing
2. Warranties

Bob Adel of Nortronics spoke on the warranty position. It was decided (see Section 3.3) that warranty conditions could be covered by user inputs and programming techniques within the model; it would be the content of the values of certain elements which would change. A review of the O&M submodel indicates that maintenance costs are in fact removed for the period of warranty. The only question is where additional costs to the Government because of warranty provisions are to be included. They could appear either in the acquisition phase or the O&M phase as a line item. The question of time-phased costing was responded to by Russ Stauffer of DRC. The consensus of the working party had been that time-phasing was a budget exercise, not a total Life Cycle Cost exercise. To include time-phasing in LCC would require the addition of many other inputs to the model including production schedules, site implementation dates, etc. To do so would unnecessarily complicate the model as it now stands. The consensus was that the outputs of the model could be used in conjunction with these other inputs and that a budget construction could be made by manual means. Upon the completion of this presentation the general meeting was adjourned.

2. REPORTS OF REDONDO BEACH WORKING GROUPS

Included in this section are the reports of the various groups which were convened at the Redondo Beach meeting in November 1974 and had worked cooperatively in the intervening time-period.

2.1 MODEL OUTPUTS

Mr. William Colcord
Lear Siegler, Inc.
4141 Eastern Avenue
Grand Rapids, Michigan

PROGRAM PHASE/SUBMODEL RELATIONSHIPS

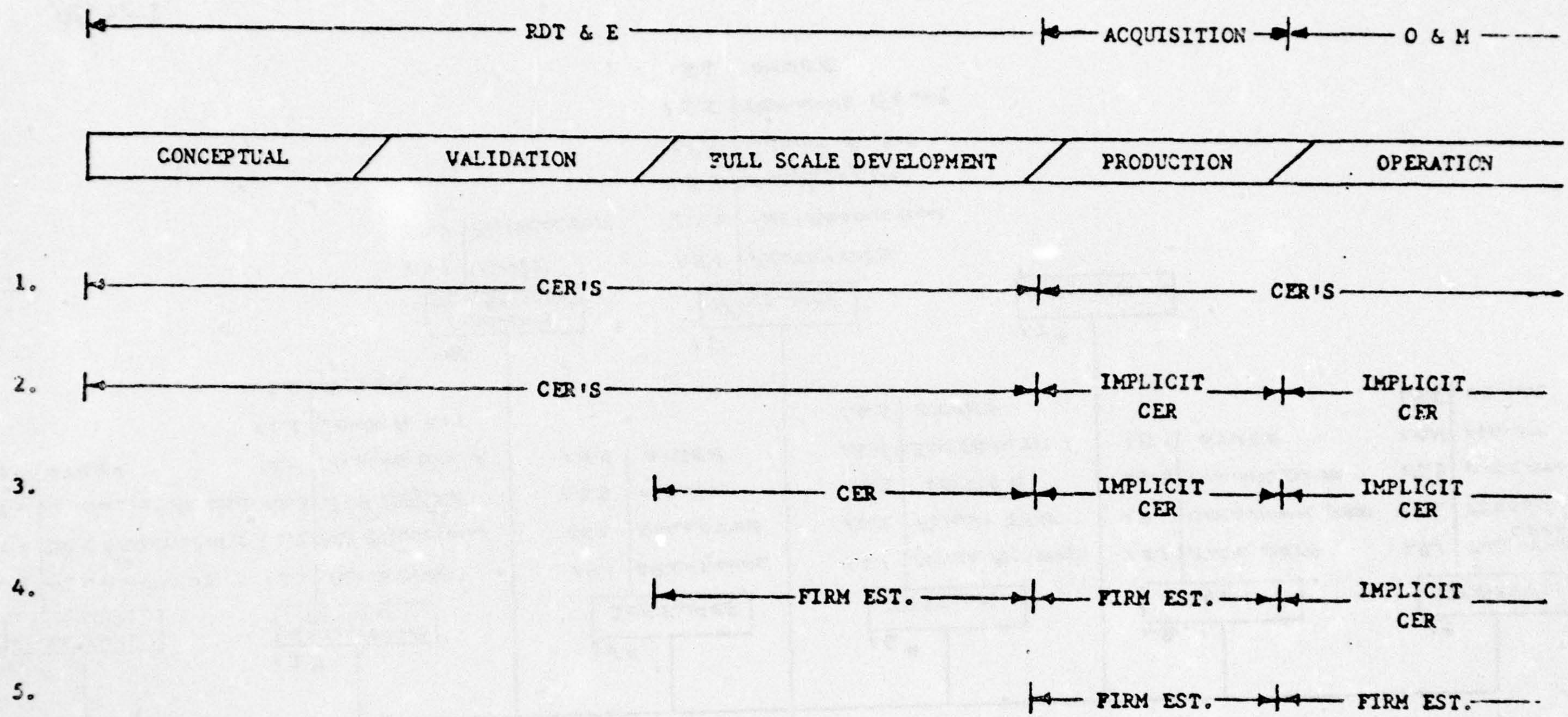
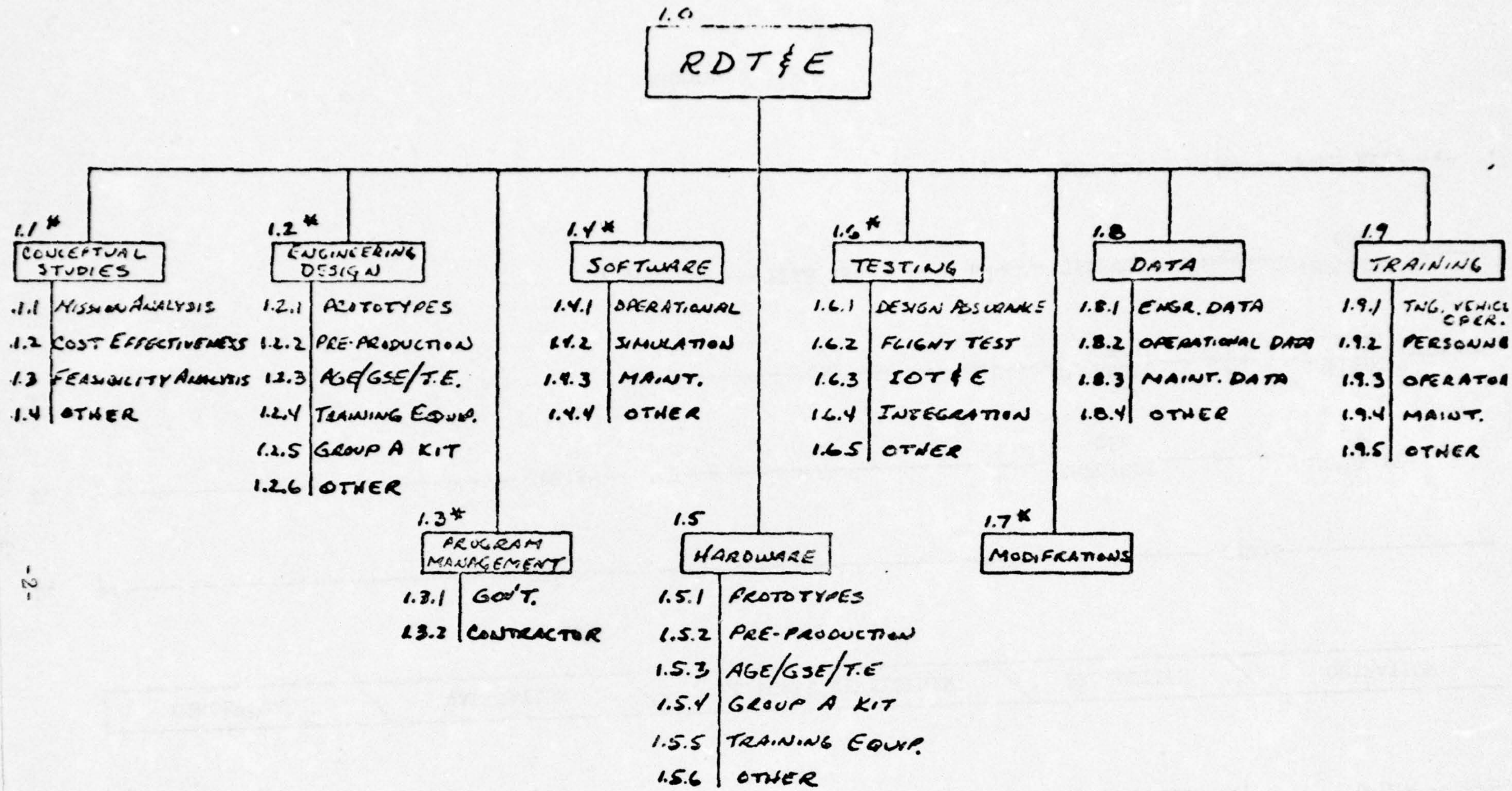


Figure 2-1

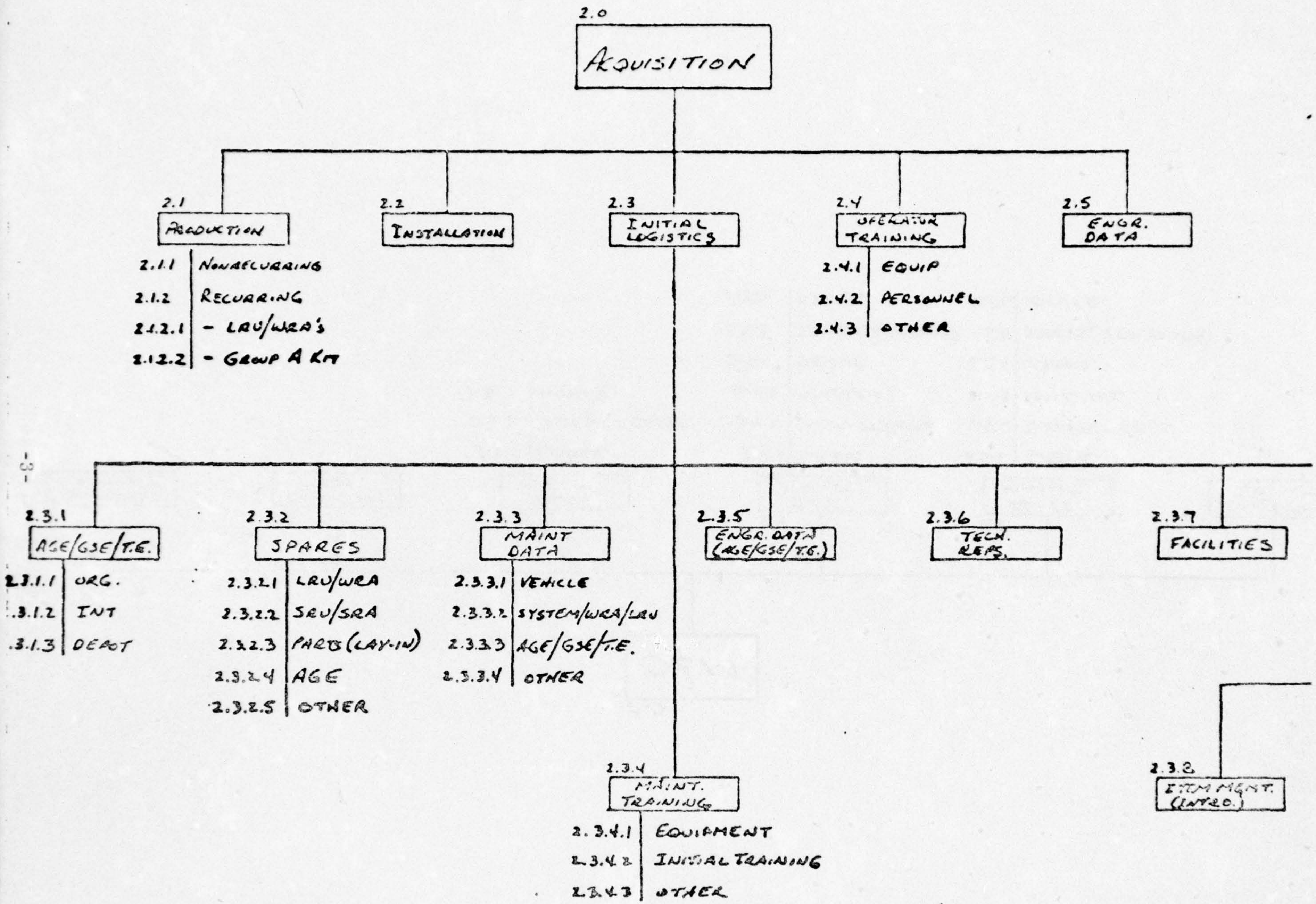


NOTE:

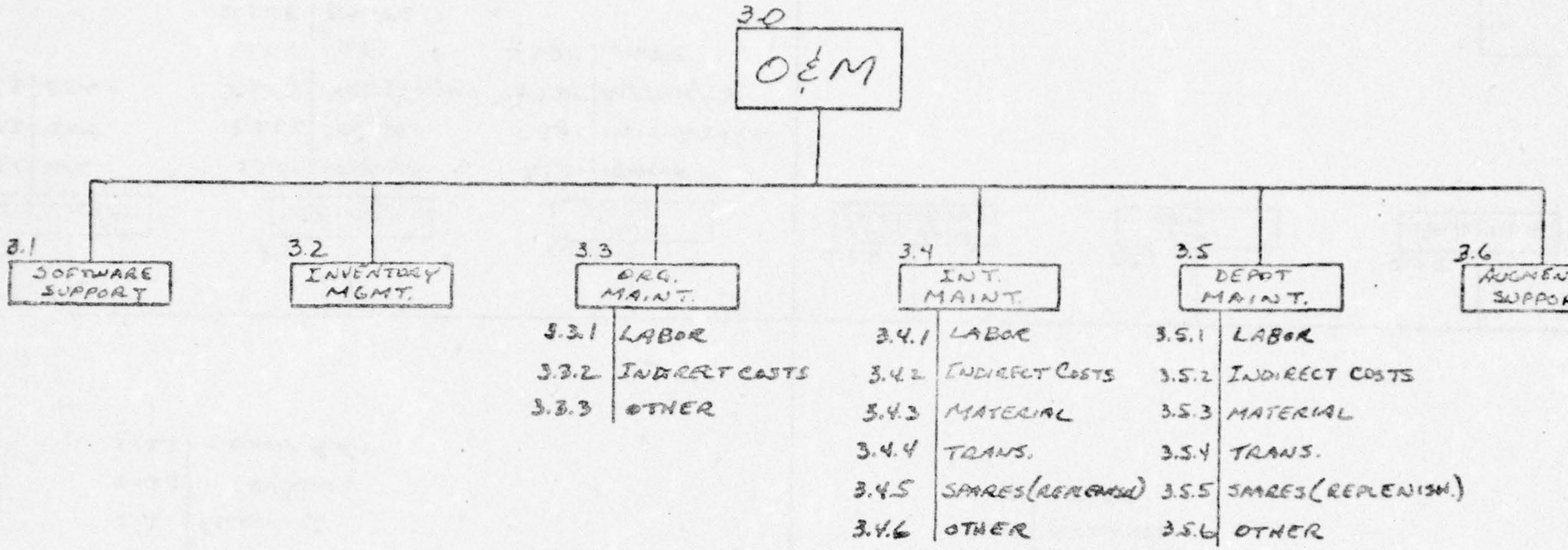
RDT&E PHASE INCLUDES ALL COSTS INCURRED PRIOR TO PRODUCTION CONTRACT AND ASSOCIATED LOGISTICS ACQUISITION.

CER ELEMENTS ARE IDENTIFIED BY AN ASTERISK

SOME AGE/GSE/T.E., TRAINING, AND DATA ELEMENTS MAY BE DEFERRED TO ACQUISITION PHASE. THEY ARE REFLECTED HEREIN TO SUPPORT IOT&E.



2.0 ACQUISITION
2.1 PRODUCTION
2.1.1 NONRECURRING
2.1.2 RECURRING
2.1.2.1 - LRU/WRA'S
2.1.2.2 - GROUP A KIT
2.2 INSTALLATION
2.3 INITIAL LOGISTICS
2.4 OPERATOR TRAINING
2.4.1 EQUIP
2.4.2 PERSONNEL
2.4.3 OTHER
2.5 ENGR. DATA
2.3.1 AGE/GSE/T.E.
2.3.1.1 ORG.
.3.1.2 INT
.3.1.3 DEPOT
2.3.2 SPARES
2.3.2.1 LRU/WRA
2.3.2.2 SRU/SRA
2.3.2.3 PARTS (LAY-IN)
2.3.2.4 AGE
2.3.2.5 OTHER
2.3.3 MAINT DATA
2.3.3.1 VEHICLE
2.3.3.2 SYSTEM/WRA/LRU
2.3.3.3 AGE/GSE/T.E.
2.3.3.4 OTHER
2.3.5 ENGR. DATA (AGE/GSE/T.E.)
2.3.6 TECH. REPS.
2.3.7 FACILITIES
2.3.4 MAINT. TRAINING
2.3.4.1 EQUIPMENT
2.3.4.2 INITIAL TRAINING
2.3.4.3 OTHER
2.3.8 ITEM MGMT. (INTRO.)


3.0
O&M
3.1
SOFTWARE SUPPORT
3.2
INVENTORY MGMT.
3.3
ORG. MAINT.
3.3.1 LABOR
3.3.2 INDIRECT COSTS
3.3.3 OTHER
3.4
INT. MAINT.
3.4.1 LABOR
3.4.2 INDIRECT COSTS
3.4.3 MATERIAL
3.4.4 TRANS.
3.4.5 SPARES (REPLENISH)
3.4.6 OTHER
3.5
DEPOT MAINT.
3.5.1 LABOR
3.5.2 INDIRECT COSTS
3.5.3 MATERIAL
3.5.4 TRANS.
3.5.5 SPARES (REPLENISH.)
3.5.6 OTHER
3.6
AUGMENTE SUPPORT

LCC SUMMARY REPORT (Sheet 1)

RTD& E

CONCEPTUAL STUDIES		CS
ENGINEERING DESIGN		DE
SOFTWARE		SWR
*TESTING		TSR
HARDWARE	TSH	
SPARES	TSS	
AGE/GSE/TE	TSER	
*LABOR		
*RDT& E MANUALS	TDR	
TECHNICAL DATA		
MODIFICATIONS (ECPs)		ECP
TRAINING		TNR
TRAINING DEVICES	TNER	
PERSONNEL	TNP	
PROGRAM MANAGEMENT		RPM
GOVERNMENT	RPMG	
CONTRACTOR	RPMC	
RDT& E SUBTOTAL		R

LCC SUMMARY REPORT (Sheet 2)

ACQUISITION COSTS

PRODUCTION			______
NONRECURRING		______	
START-UP	CSU		
TOOLING & TEST EQUIP.	TTEA		
RECURRING		SRAC	
INSTALLATION			CINST
OPERATOR TRAINING			______
EQUIPMENT (SIMULATOR'S, ETC.)		______	
PERSONNEL		______	
TECHNICAL DATA			NTOD (1% TDA)
INITIAL LOGISTICS COSTS			______
AGE/GSE/TE		______	
SPARES		______	
AVE	______		
AGE/GSE/TE	______		
TECHNICAL PUBLICATIONS		______	
AVE	______		
AIRFRAME	______		
AGE	______		
TECHNICAL DATA (AGE/GSE/TE)		______	
TRAINING (MAINT.)		______	
EQUIPMENT	TNEA		
INITIAL TRAINING	TNA		
TECH. REPS.		CFE	
FACILITIES		FACA	
Item Mgmt. (Intrc)		*IMA*	
ACQUISITION SUBTOTAL			A

LCC SUMMARY REPORT (Sheet 3)

O&M COSTS (PIUP YEARS)

SOFTWARE SUPPORT		
INVENTORY MGMT.		
ORGANIZATIONAL MAINT.		OM_1
LABOR	DL_1	
INDIRECT COSTS	$OL_1 + GA_1$	
INTERMEDIATE MAINT.		OM_2
LABOR	DL_2	
INDIRECT COSTS	$OL2 + GA_2$	
MATERIAL	DM_2	
TRANSPORTATION	T_2	
SPARES (REPLENISHMENT)	$RS2$	
DEPOT MAINT.		OM_3
LABOR	DL_3	
MATERIAL	DM_3	
INDIRECT COSTS	$OL3 + GA_3$	
TRANSPORTATION	T_3	
SPARES (REPLENISHMENT)	RS_3	
WARRANTY	WC_3	
*AUGMENTED SUPPORT		
O&M SUBTOTAL		OM
TOTAL PROGRAM COST		LCC

AGE/GSE/TE REQUIREMENTS REPORT

PARAMETER / ITEM	AVAIL.	LOADING	TOTAL QTY	UNIT COST	TOTAL UNIT COST	NONREC. COST
ORG. MAINT.						
ITEM #1						
ITEM #2						
INT. MAINT.						
ITEM #3						
ITEM #4						
ITEM #5						
DEPOT MAINT.						
ITEM #3						*
ITEM #6						
ITEM #7						
TOTAL AGE COST						

*Previously Listed

LCC DETAIL LOGISTICS REPORT

LOCATION		AGE/GSE/TE	SPARES	LABOR	FACILITIES	TOTAL
ORIG. SITE	# 1					
	# 2					
	# 3					
	# 4					
	# 5					
	# 6					
Subtotal						
INT. SITE	# 1					
	# 2					
	# 3					
	# 4					
Subtotal						
DEPOT SITE	# 1					
Subtotal						
Total						

SPARES REQUIREMENTS REPORT

PARAMETER / ASSEMBLY		MTBMA	P	TAT	QPS	NRTS	QTY	UNIT COST	EXTENDED COST
LRU	#1								
	#2								
	#3								
	#4								
SRU	#1								
	#2								
	#3								
	#4								
	#5								
	#6								
							TOTAL SPARES COST		

LCC DETAIL SYSTEM REPORT

CATEGORY / ITEM	AGE/GSE/TE	SPARES	LABOR	FACILITIES	TOTAL
LRU #1					
#2					
#3					
#4					
SRU #1					
#2					
#3					
#4					
#5					
#6					
TOTAL COST					

2.2 DATA INPUT STANDARDIZATION

Mr. Robert A. Rodriguez
Litton Guidance and Control
5500 Canoga Avenue
Woodland Hills, California

RDT&E PHASE INPUTS

LINE	SYMBOL	DESIGNATION	VALUE/RANGE	COMPUTES
R1	TI	Technology Index		CS,RPM
R2	EH	Cost of Engineering Hours		CS
R3	SAH	Cost of Systems Analysis Hours		CS
R4	CST	Cost of Computer Simulation Time		CST
R5	ACC	INS Accuracy (Required)		DE
R6	MTBF	Mean Time Between Failures (Required)		DE,TSR
R7	MTTR	Mean Time to Repair (Required)		DE
R8	AT	Alignment Time (Required)		DE
R9	E	Non-Dimensional Number Proportional To Environmental Stress		DE
R10	DEP	Known Design Engineering Cost of Previous System of Similar Design		DE
R11	PROP	Proportionality Factors	1,2,3,4 (Index)	DE
R12	PC	Production Cost Per Unit of Prime Hdwr.		ECP,SWR
R13	PCZ	Production Cost of AGE/GSE/TE		ECP
R14	NV	Number of Vehicles		ECP
R15	QPV	Quantity of INS per Vehicle	$RTDR_{ti}$	ECP,$RTDR_{ti}$
R16	VEC	Cost to Alter Each Vehicle		ECP
R17	PROP	Proportionality Factors	5,6 (Index)	ECP
R18	NECP	Number of Engineering Change Proposals		ECP
R19	RPMC	Contractor Program Management Cost		RPM
R20	RPM	Government Cost of Management of a Comparable System		RPM
R21	SWRP	Cost of Software for Previous System		SWR
R22	PCP	Cost of Production Hardware for Previous System of Similar Design		TSR(Alt.)
R23	PROP	Proportionality Factor	7(Index)	SWR
R24	CTD	Average Cost per Page of Technical Data		TDR
R25	TDP	Number of Technical Data Pages		TDR
R26	CD	Average Cost per Page of Drawings		TDR
R27	TDD	Number of Pages of Drawings		TDR
R28	NTI	Number of Training Units		TNR
R29	DPC	Development of Production Cost per Unit of Training Devices		TNR
R30	NTL	Number of Training Locations		TNR
R31	DPCA	Development Production Cost per Set of AGE/STE/TE		TNR
R32	TVOC	Test Vehicle Cost Per Operating Hour		TNR
R33	TVOPT	Test Vehicle of Operation Hours for Training		TNR
R34	LTP	Length of Test Program in Months		TNR,TSR
R35	MCM	Manpower cost per Month(Instructors)		TNR
R36	GTNH	Ground Training Hours with Prime Equip.		TNR
R37	TNCH	Test Equipment Training Hours		TNR
R38	MHG	Personnel Cost per Training Hour		TNR
NOTE*				
R40	NTH	Number of Units of Primary Hdwr. Used for Testing.		TSR
NOTE*				
R42	TVOP	Test Vehicle Operating Hours per Month		TSR

NOTE** DPC (R29 & R39) Believed to be Redundant.

LINE	SYMBOL	DESIGNATION	VALUE/RANGE	COMPUTES
R43	SF	Safety Factor (Assurance of Spares Availability during Testing)	SF1	TSR
R44	DPCZ	Production Cost (During Development) of Special Engineering Test Equip.		TSR
R45	NTH	Number of Test Hardware Sets,		TSR
R36	COH	Cost per Test Operating Hours (Including cost of Data Reduction).		TSR

ACQUISITION PHASE INPUTS

LINE	SYMBOL	DESIGNATION	VALUE/ RANGE	COMPUTES
A1	CTE_j	Cost of the jth item of Tooling or Test Equipment.		TTEA
A2	QTE_j	Quantity of the jth Item of tooling or Test Equipment Required Achieve Production Rate.		TTEA
A3	NS	Quantity of Systems Purchased		SRAC
A4	UC_q	Average Unit Cost per System Based on 9 Systems Purchased.		SRAC
A5	NI	The number of Installations		CINST
A6	CI	The Average cost per Installation to Install a system in the using Vehicle or Facility		CINST
A7	$CSUA_j$	Cost of the jth Item of Program Start up Activity.		CSU
A8	NRS_k	Number of Repair Stations at the Kth Level of Maintenance	K=1,2,3	TSEA
A9	SOH	Average Operating Hours per System per Month		TSEA
A10	$MTBF_i$	Mean Time Between Failures per Reliability Predictions or Specified Program Requirements.		TSEA
A11	K1	The ratio of the number of anticipated Maintenance Actions to the calculated number of Failures		TSEA
A12	QPS_i	Quantity of the ith LRU or SRU per System.		TSEA
A13	$NOPS_k$	Quantity of Operating Systems maintained at the Kth level of maintenance		TSEA
A14	$SETT_{ijk}$	Average hours per maintenance action that the jth item of support equipment will expend from fault isolation through acceptance testing of the ith LRU or SRU at the Kth level of maintenance.		TSEA
A15	CF	Calibration Frequency		
A16	$SECT_{ijk}$	Average hours per calibration that the jth item of support equipment will be employed in calibration of the ith LRU or SRU at the Kth level of maintenance.		TSEA
A19	TDG	Number of pages of AGE T.O.'s		TDA
A20	TDIC	One Time Cost to Introduce a T.D. into Inventory.		TDA
A21	$TNEA_k$	Training Equipment Acquisition Cost at the Kth level of maintenance		TDA
A22	NAME	Identification of each item to be spared by location.		SPHA
A17 (See R24)				
A18 (See R25)				

ACQUISITION PHASE INPUTS

LINE	SYMBOL	DESIGNATION	VALUE/ RANGE	COMPUTES
A23	NOS	Number of Operating Systems.		SPHA
A24	QPS_i	Quantity of the ith LRU or SRU per system.		SPHA
A25	$MTBMA_i$	Meantime between Maintenance Actions for the 1th LRU or SRU		SPHA
A26	$NRTS_i$	The percent of failures of the ith LRU or SRU that are returned to the Depot for Repair.		SPHA
A27	DTAT	Depot Turn Around Time		SPHA
A28	RTS_i	The percent of failures of the ith LRU or SRU that are repaired at the Intermediate Level Repair		SPHA
A29	ITAT	Intermediate Level Turn Around Time		SPHA
A30	C_i	Cost of the ith LRU or SRU		SPHA
A31	IL	The number of inventory locations of each type.		SPHA
A32	DISCL	Listing of the Dicardable LRU's or SRU's.		SPHA
A33	$CCOND_i$	Cost of the ith Discardable Item		SPHA
A34	PIUP	Program Life (Program Inventory Usage Period)		SPHA
A35	ICL_k	Initial Course Length		TNA
A36	LRI_k	Instructor Labor Rate		TNA
A37	NI_k	Total Number of Instructors		TNA
A38	NS_k	Number of Students per Course		TNA
A39	LRS_k	Student Labor Rate		TNA
A40	CP	Course Preparation Cost		TNA
A41	NC_k	Number of Courses to be Given		TNA
A42	CM_k	Course Material Cost		TNA
A43	NFE	Number of Field Engineering man-months required per Repairs Station		CFE
A44	CFER	Cost per Field Engineer (#/month)		CFE
A45	NRS	Number of Repair Stations Requiring Field Engineering Support		CFE
A46	$CFACA_i$	Cost of the jth new Facility		FACA
A47	$QFACA_i$	Quantity of the ith New Facility		FACA
A48	NPTA	Number of new Part Types		IMA
A49	NATA	Number of New Assembly Types		IMA
A50	IMCA	Cost to Introduce a New Part Type or New Assembly Type into Government Inventory.	Standard	IMA

O&M PHASE INPUTS

LINE	SYMBOL	DESIGNATION	VALUE/ RANGE	COMPUTES
Ø1	NRS_1	Number of Organizational Level Stations.		OM1t
Ø2	$MTTRO_1$	Mean time to Repair at Organization Station for the ith item		DL_{1ti}
Ø3	DLRO	Direct Labor Rate at Organization Station		DL1ti
Ø4	LORO	Overhead Labor Rate at Organization Station		OL_{1ti}
Ø5	GARO	General Administrative Rate at Organization Station.		GA1ti
Ø6	NV	Number of Inventory Vehicles in the tth year.	Multi-Use,	$RTOR_{ti}$, OM_{3t}
Ø7	See R15			
Ø8	QPS_i	Number of ith item per INS	Multi-Use,	$RTOR_{ti}$, $RTDR_{ti}$
Ø9	SOH_t	System Operating Hours per month in the tth year.	Multi-Use	TRDRti, RTORti
Ø10	$NRTSO_i$	Not Reparable Rate at Organization Station for the ith item		RTIRti
Ø11	$MTBR_i$	Mean Time Between Removal for ith item.	Multi-Use	RTIRti
Ø12	RIF_{ti}	Reliability Improvement Function in tth year for the ith item.	Multi-Use	$RTIR_{ti}$
Ø13	RTOKi	Retest OK rate at Intermediate Station for the ith item		DL_{2ti}
Ø14	PLVI	Percent Labor Verification at Intermediate Station		DL_{2ti}
Ø15	$MTTR_i$	Mean Time to Repair at Intermediate Station for the ith Item		DL2ti
Ø16	DLRI	Direct Labor Rate at Intermediate S Station		DL_{2ti}
Ø17	$MCPR_{2i}$	Material Cost Per Reqpair at Intermediate Station for ith Item.		DM_{2ti}
Ø18	NRS_2	Number of Intermediate Stations		OM_{2t}
Ø19	LORI	Overhead Labor Rate at Intermediate Station		
Ø21	$RTDR_{ti}$	Return to Depot Rate in tth year for the ith item.		T_{3ti}
Ø22	GARI	General Administrative Rate at Intermediate Station		GA_{2ti}
Ø23	$NRTSI_i$	Not Reparable Rate at Intermediate Station for the ith item		T_{2ti}, $RTDR_{ti}$
Ø24	POI	Percent Overseas Intermediate Stations		T_{2ti}, $_{3ti}$
Ø25	SCO	Shipping Cost Overseas	Standard	T_{2ti}, 3ti
Ø26	SCC	Shipping Cost CONUS	Standard	T2ti, 3ti
Ø27	Wi	Weight of ith item		T2ti, 3ti
Ø28	COND2	Condemnation Rate at Intermediate Station for ith item		RS2ti

O&M PHASE INPUTS

LINE	SYMBOL	DESIGNATION	VALUE/ RANGE	COMPUTES
Ø29	NRS3	Number of Depot Stations		
Ø32	See R15			
Ø34	TF	Transition Factor		DL3ti,DM3ti
Ø35	W3ti	Cost in year t for item i of a warranty (supplied by proposer)		WC3ti
Ø36	RTOKDi	Retest OK Rate at Depot for ith item		DL3ti DL3ti
Ø37	PLVD	Percent Labor Verification at Depot		DL3ti
Ø38	MTTRD	Mean Time to Repair at Depot for the ith item		DL3ti
Ø39	DLRD	Direct Labor Rate at Depot		DL3ti
Ø40	RPIFi	Repair Process Improvement Function on the ith item		DL3ti
Ø41	MCPR3i	Material Cost per Repair at Depot for the ith item.		DM3ti
Ø42	See Ø24			
Ø43	COND3i	Condemnation Rate at Depot for ith item		RS3ti
Ø44	PCti	Production Cost in tth year for ith item.		RS3ti
Ø46	GARD	General Administrative Rate at Depot		GA3ti
Ø47	LORD	Labor Overhead Rate at Depot		OL3ti

2.3 INPUT TECHNIQUES

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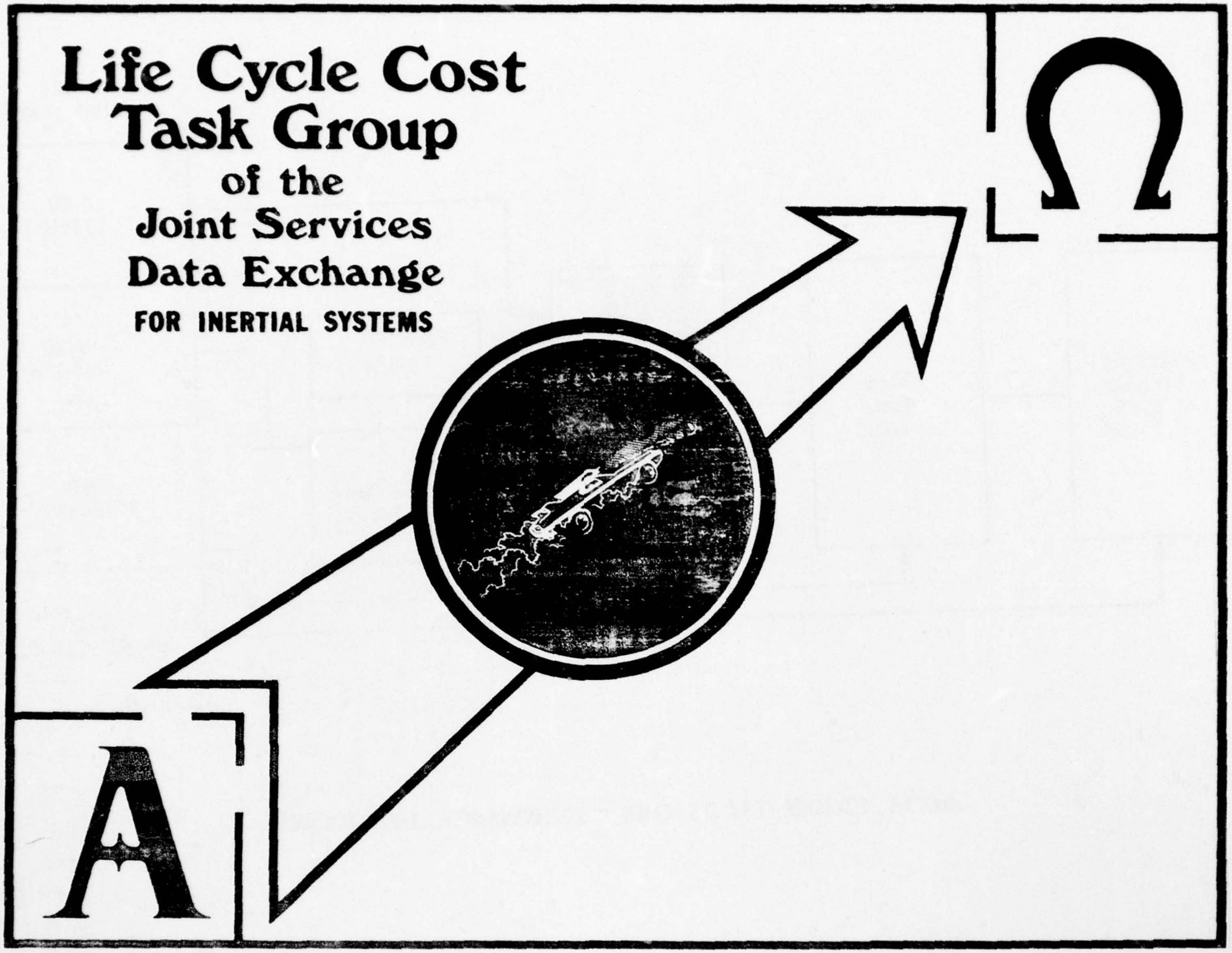
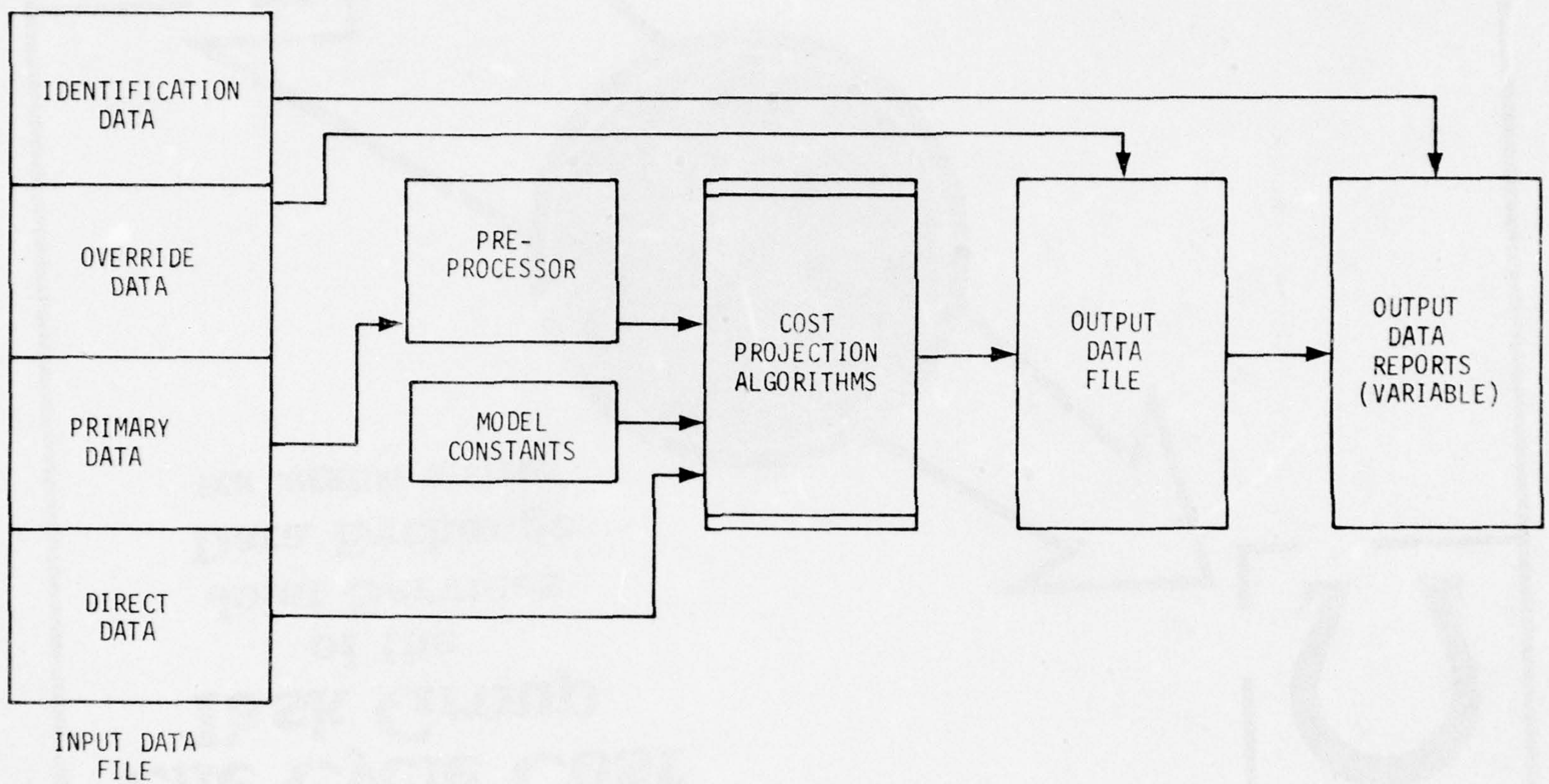
Service Division
Collins Radio, RI
Cedar Rapids, Iowa


Life Cycle Cost
Task Group
of the
Joint Services
Data Exchange
FOR INERTIAL SYSTEMS
A
Ω

MODEL PROGRAMMING - PROJECTED MODEL FLOW



(ORIGINAL FORM)

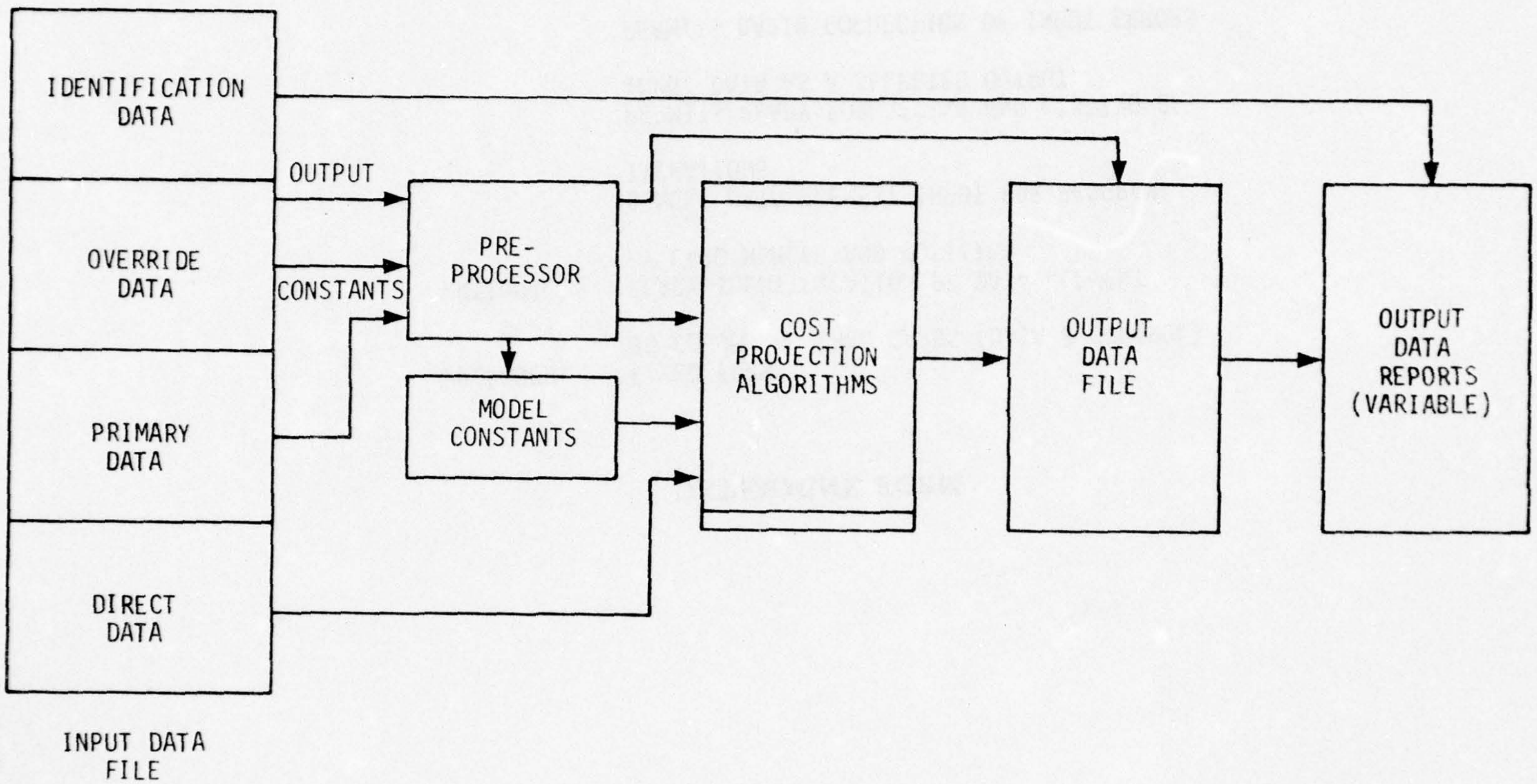
INPUT DATA TYPES

IDENTIFICATION DATA	- PROVIDES OUTPUT REPORTS HEADER AND/OR TITLING INFORMATION
OVERRIDE DATA	- PRE-COMPUTED DATA PROVIDED AS PROGRAM INPUT. PERMITS SELECTIVE ABORTING OF COMPUTATIONS
PRIMARY DATA	- REQUIRES PRE-PROCESSING FOR USE IN ALGORITHMS (E.G. DATA FOR SUB-EQUATIONS)
DIRECT DATA	- USABLE BY ALGORITHMS WITHOUT ADDITIONAL PROCESSING

WORKING GROUPS/TASKS

INPUT DEVELOPMENT	(1)	LIST/CONSOLIDATE ALL ALGORITHM VARIABLES
	(2)	DETERMINE REQUIRED DETAIL
	(3)	IDENTIFY SOURCE (E.G. INPUT, CALCULATION, ETC)
	(4)	DEVELOP CALCULATION PROCESS
OUTPUT DEVELOPMENT	(1)	IDENTIFY POTENTIAL OUTPUT REQUIREMENTS
	(2)	COORDINATE WITH INPUT GROUP FOR DETAIL
	(3)	DESCRIBE OUTPUT DATA FILE
INPUT TECHNIQUES	(1)	DETERMINE FORM
	(2)	DESCRIBE OVERRIDE TECHNIQUE
	(3)	DEFINE DEPLOYMENT CONCEPT
	(4)	DEFINE MAINTENANCE CONCEPT
	(5)	PROVIDE FOR ITERATION CAPABILITY

MODEL PROGRAMMING - PROJECTED MODEL FLOW



(MODIFIED)

DETERMINE FORM

PROPOSED: FIXED FORM
80 COLUMN PUNCHED CARDS (DATA & CONTROL)

RATIONALE: READY IDENTIFICATION OF DATA ELEMENT BY CARD NUMBER AND POSITION

SINGLE DATA ELEMENT INPUT FOR PROGRAM ITERATIONS

PERMITS READY FORMATTING AND LISTING OF INPUT DATA AS A SELECTED OUTPUT

PERMITS RAPID CORRECTION OF INPUT ERRORS

INPUT DATA CARDS

CARD NUMBERING SCHEME
CARD SERIES

000	COMMON DATA (MODEL CONSTANTS)
100	RDT&E ALGORITHM
200	ACQUISITION ALGORITHM
300	O&M ALGORITHM
400	OVERRIDE DATA
500	DEPLOYMENT CONCEPT
600	IDENTIFICATION DATA

INPUT DATA CARDS (CONT)

<u>CARD NUMBERING SCHEME</u>
<u>CARD SUFFIXING</u>

(1) CARD "PACKAGES" - FOR DATA REQUIREMENTS EXCEEDING A SINGLE CARD'S CAPACITY

(2) CARD REFERENCING - PROVIDES CROSS-REFERENCE CAPABILITY (E.G. SUPPORT EQUIPMENT/HARDWARE APPLICATIONS)

(3) INDEXING (SUBSCRIPTING) - FOR MULTIPLE ITEMS ON MULTIPLE CARDS, COMBINING SUFFIX WITH CARD FIELD POSITION PROVIDES ITEM INDEX

COMMON DATA

CARD SERIES 0XX

XX	- IDENTIFIES SPECIFIC SET OF MODEL CONSTANTS TO BE MODIFIED
DATA FIELDS	- QUANTIFIES THE CONSTANTS

OVERRIDE TECHNIQUE

OVERRIDE DATA
CARD SERIES 4XX

XX	- IDENTIFIES SPECIFIC OUTPUT DATA CATEGORY (E.G. SPARING LEVELS AT INDIVIDUAL INVENTORY LOCATIONS)
SUFFIX	- IDENTIFIES SPECIFIC DATA ELEMENT WITHIN A CATEGORY (E.G. SPARING LEVEL OF A PARTICULAR LRU/SRU)
DATA FIELD	- QUANTIFIES THE OVERRIDE DATA

DEPLOYMENT CONCEPT

CARD SERIES 500

500 - DEFINES EACH ORGANIZATION AS HAVING A NUMBER OF VEHICLES (NV) ASSIGNED WITH A QUANTITY OF SYSTEMS PER VEHICLE (QPV), A RESPONSIBLE INTERMEDIATE ACTIVITY (IMA), AND A RESPONSIBLE DEPOT

SUFFIX - INDEXES MULTIPLE 500 CARDS

DATA FIELDS (EXAMPLE) -

ORGANIZATION	NV	QPV	IMA	DEPOT
A	h	P	t	Y
B	h	Q	t	Y
C	h	Q	u	Z
D	i	P	u	Z
E	j	R	u	Z

MAINTENANCE CONCEPT

MAINTENANCE LEVEL	MAINTENANCE ACTION		
	REMOVED	REPAIRED	CONDEMNED
ORGANIZATIONAL	REMK = 1	$000.0 \leq NRTS1 < 100.0$	NONE
INTERMEDIATE	REMK = 2	$000.0 \leq NRTS2 < 100.0$	$COND\ 2 \neq 000.0$
DEPOT	REMK = 3	$000.0 \leq COND\ 3 < 100.0$	$COND\ 3 = 100.0$

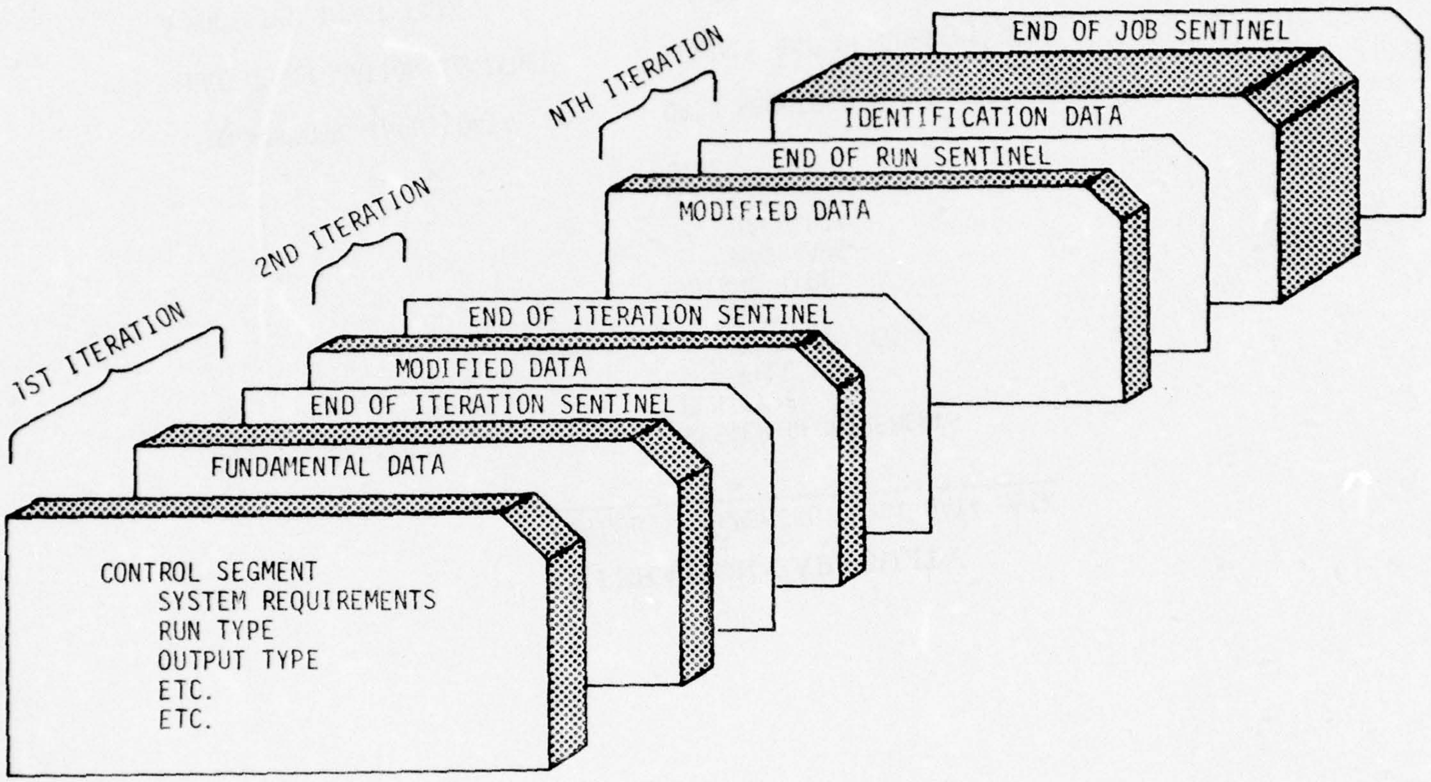
ITERATION CAPABILITY

METHOD - SEGMENTED INPUT DATA DECK

CONTROL SEGMENT	SYSTEM REQUIREMENTS
	RUN TYPE
	    FULL LCC
	    PARTIAL LCC
	    ETC.
	OUTPUT TYPE
	    MAG TAPE
	    HARDCOPY
	    ETC.
	OTHER

FUNDAMENTAL INPUT DATA	DATA REQUIRED FOR FIRST ITERATION
END OF ITERATION SENTINEL	SIGNALS END OF CURRENT DATA
MODIFIED INPUT DATA	CHANGES REQUIRED FOR SECOND ITERATION (ALL OTHER DATA REMAINS UNCHANGED)
END OF RUN SENTINEL	SIGNALS END OF ALL DATA
IDENTIFICATION DATA	PROVIDES HEADERS/TITLING
END OF JOB SENTINEL	SIGNALS END OF PROCESSING

SEGMENTED DATA DECK



IDENTIFICATION DATA

CARD SERIES 60X

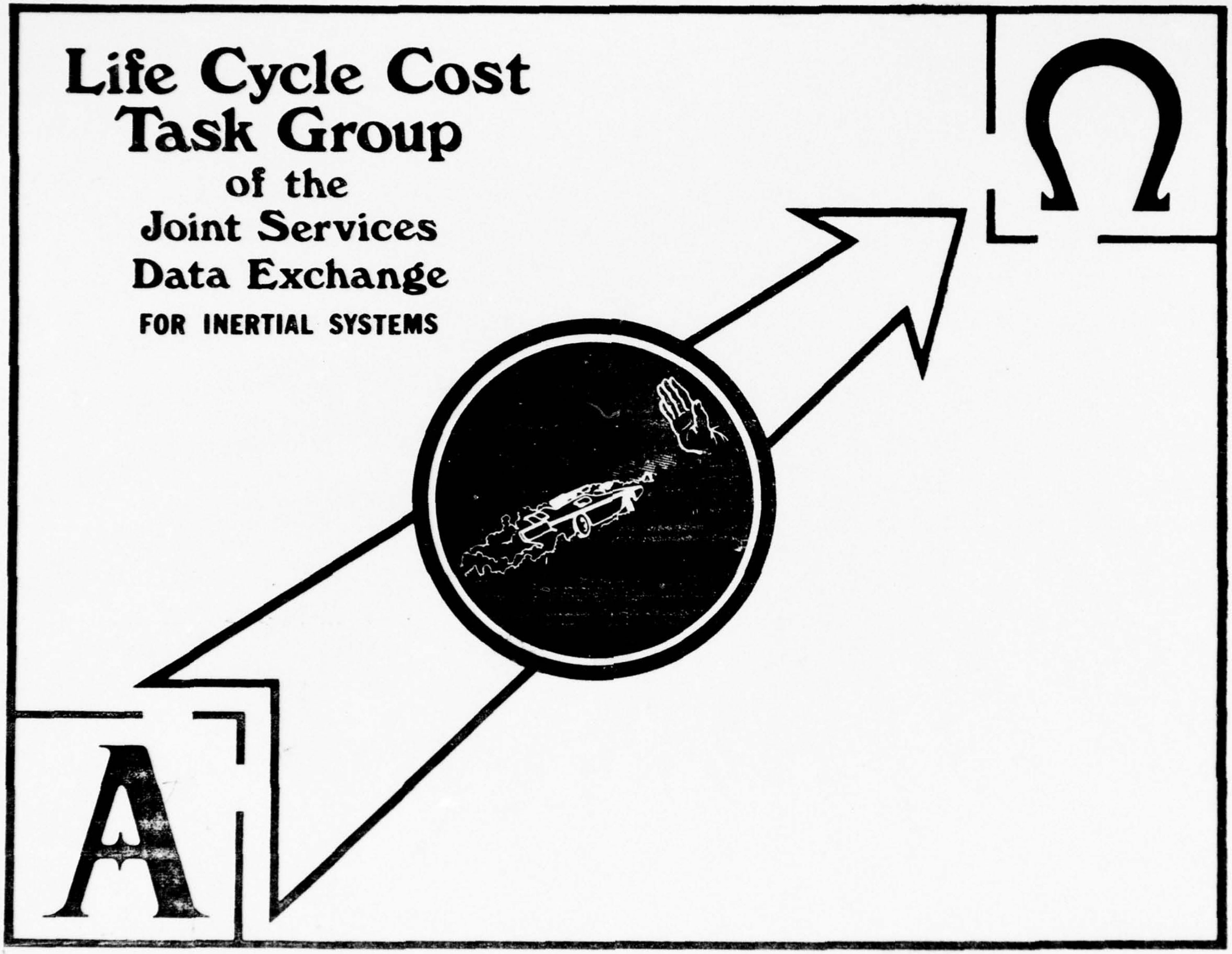
X	- DEFINES IDENTIFICATION DATA RELATED TO A SPECIFIC OUTPUT
SUFFIX	- PROVIDES A SEQUENTIAL "PACKAGE" OF IDENTIFICATION DATA
DATA FIELDS	- CONTAINS THE APPLICABLE IDENTIFICATION DATA

Life Cycle Cost Task Group

of the

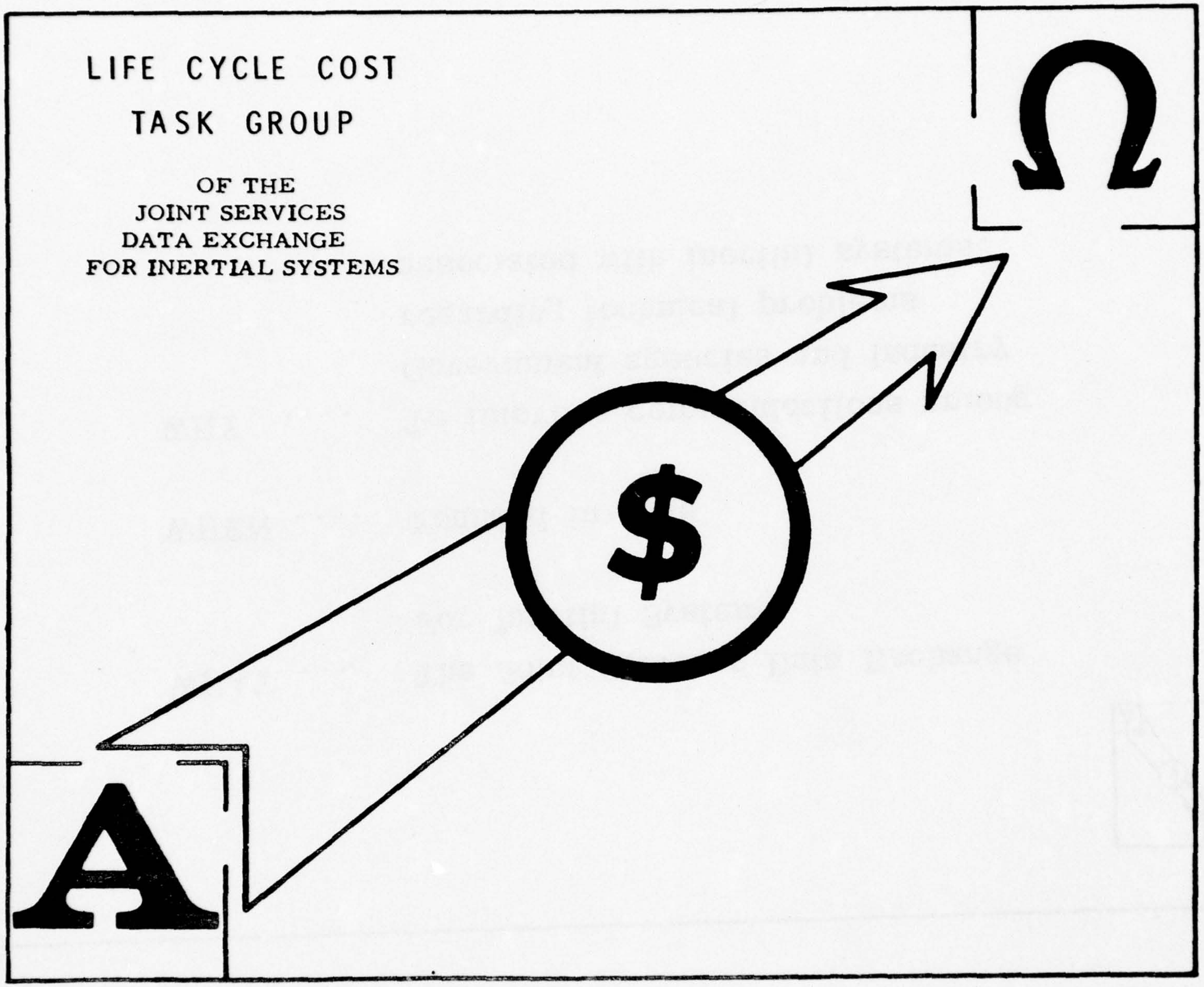
Joint Services Data Exchange

FOR INERTIAL SYSTEMS



2.4 LIFE CYCLE COST TASK GROUP DESCRIPTION

Mr. Robert E. Adel
M&ILS Management Unit
Northrop Electronics
2301 West 120th Street
Hawthorne, California


LIFE CYCLE COST
TASK GROUP
OF THE
JOINT SERVICES
DATA EXCHANGE
FOR INERTIAL SYSTEMS
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A

WHAT	The Joint Services Data Exchange For Inertial Systems
WHEN	Founded in 1969
WHY	To improve communications among Government agencies and industry regarding technical problems associated with inertial systems.

INERTIAL SYSTEM COST ASPECTS ARE A MAJOR CONSIDERATION

August, 1973

Results of a JSDE special committee meeting

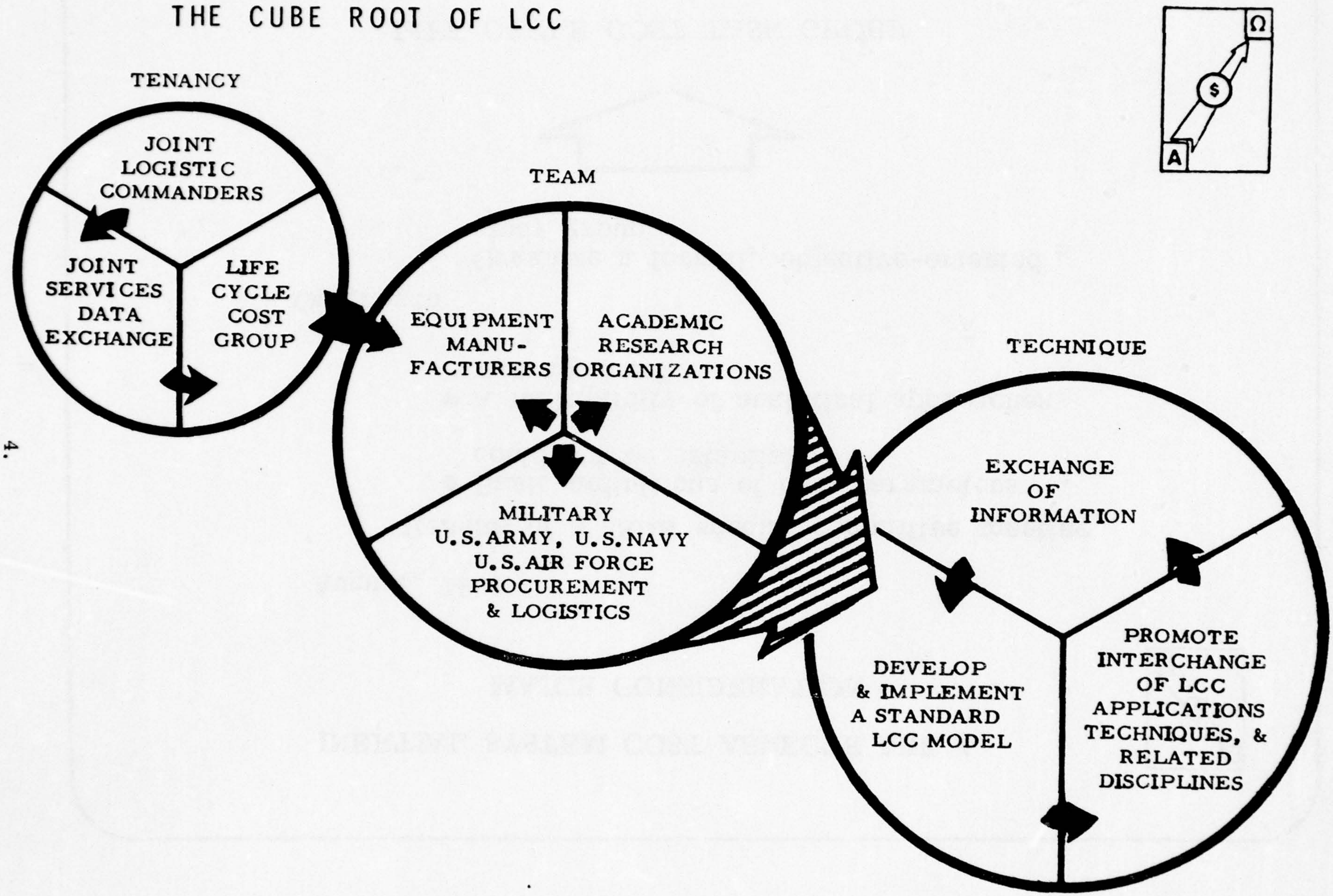
- Basic definitions of cost parameters could not be established
- A multiplicity of analytical approaches was apparent

Outgrowth

Organize a formal, objective-oriented study group

LIFE CYCLE COST TASK GROUP

THE CUBE ROOT OF LCC



LCC TASK GROUP OPERATION

EXECUTIVE COMMITTEE

2 Members from the Government

2 Members from Industry

2 Members from Academic/Research

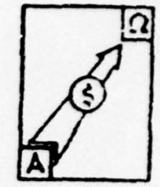
- Elect two committee members as task group chairman and vice-chairman
- Establish agendas for the quarterly meetings
- Schedule speakers
- Coordinate interim work assignments of the general members

Meetings are divided equally between:

Presentation of papers

Working sessions to prepare and implement a standard model

MEMBERSHIP IS OPEN TO ANYONE INTERESTED



MILESTONES IN THE LCC TASK GROUP ACTIVITIES

Jan, 1974	Numerous LCC models presented and discussed. Working models distributed to members.
Apr, 1974	Divided into working parties to identify the requirements for a standard model.
Jun, 1974	Developed algorithms to mathematically express the life cycle cost incurred during RDT&E, acquisition, and O&M.
Aug, 1974	Task group meeting was held in conjunction with the 8th annual meeting of the parent group. Continued compilation of the model algorithms.
Nov, 1974	Model input requirements and output formats were defined.
Feb, 1975	(Scheduled) All ambiguities and duplications in the algorithms will be identified and eliminated. Input and output formats will be finalized. Computer programming will begin.

INTERCHANGE VEHICLES

PAPERS
- Department of Defense
- Senior Military Commands
- Key Industrial Personnel

TOPICS
- Existing LCC Models
- Development of Cost Estimating Relationships
- Application of LCC

PRESENTORS
- John D. S. Gibson, ASD/ACL
- W. L. Smith, HQ USAF/LGPLA
- Brig. Gen. Robert Duffy (Ret), CSDL
- Harold S. Balaban, ARINC
- Russell Shorey, ODDR&E

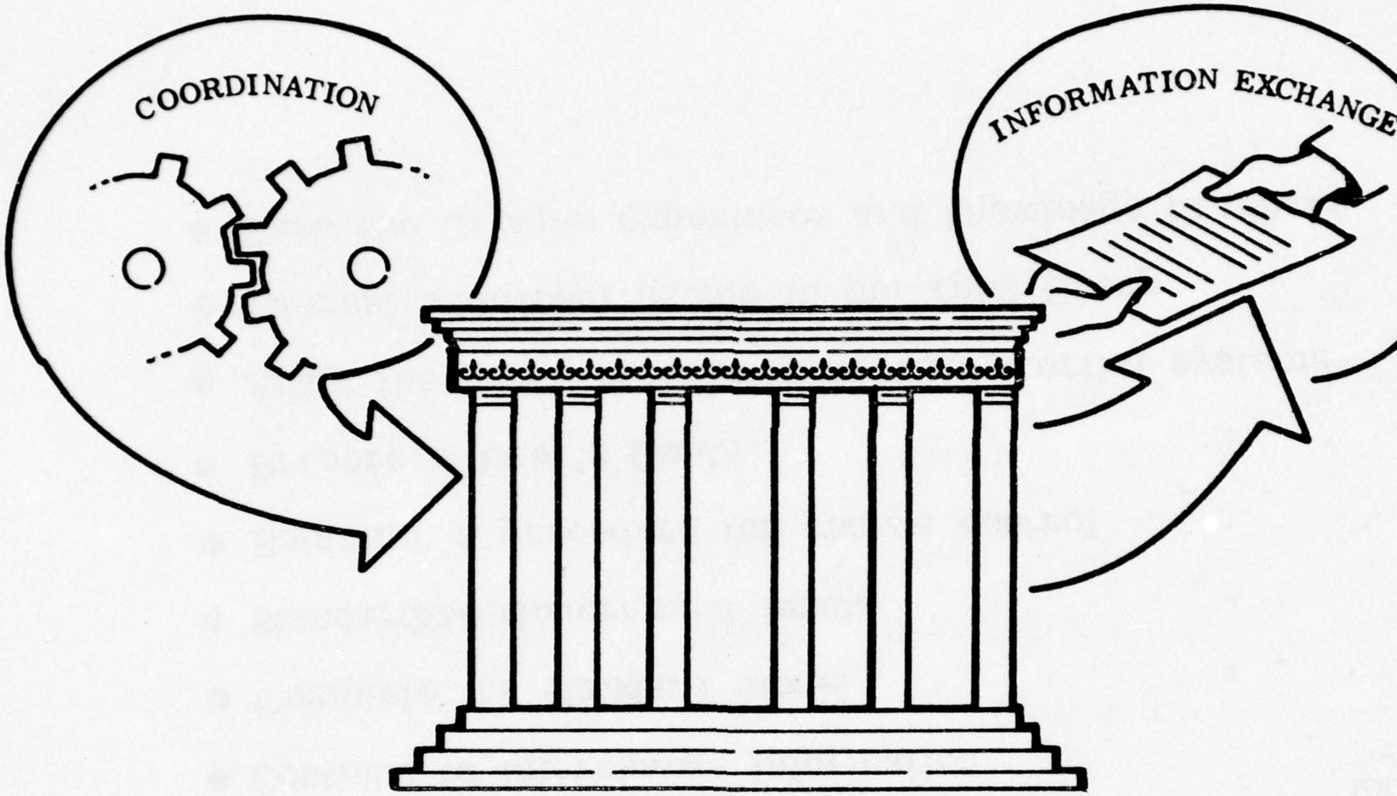
LCC MODEL CHARACTERISTICS

- Basic Accounting Model
- Flexible - May be used by Military, Industry, Research
- Can predict LCC at any phase of the program
- Provides for input data at any level
- Creates a Data File - User may create any output format he desires (in addition to "standard" formats)
- "Fixed" Parameters can be readily replaced or modified

It is planned to program the model, debug the program, run sensitivity tests, and compare the model with other models in 1975.

FUTURE PLANS

- Continue to interchange information
- Complete the standard model
- Standardize Government inputs
- Establish a procedure for change control
- Prepare a User's Guide
- Adapt the model to uses other than inertial systems
- Interest additional people in the Task Group
- Pass the Group's experience and knowledge to others



☆ LCC FORUM

3. REPORTS OF ST. PETERSBURG WORKING GROUPS

This section contains duplicates of the informal presentation material used to report working party results to the total task group.

3.1 WORKING PARTY I

WORKING GROUP 1

STANDARDIZATION OF VARIABLE NAMES

- RECOMMENDATIONS

  USE ITEMS DESCRIBED IN TUESDAY'S HANDOUT

  UPDATED VERSION OF ALGORITHMS (WITH STANDARD ELEMENTS) HAS BEEN STARTED.

  ADDITIONS FROM TODAY'S MEETING WILL BE INCORPORATED.

- RATIONALE – PROMOTE EARLY START-UP OF PROGRAMMING

- ~~IM~~ IMPACT ON ALGORITHMS – CLARITY.

INTERNAL USE ONLY

WORKING GROUP I

AREAS OF EFFORT

- COMPUTER CONSTRAINTS
- CONTINUATION OF I/O EFFORT
- STANDARDIZATION OF VARIABLE NAMES

INTERNAL USE ONLY

COMPUTER CONSTRAINTS

- RECOMMENDATIONS

  EACH USER ADVISE KEITH GIBSON OF CONSTRAINTS RELATED TO:

  HARDWARE
  CORE AVAILABILITY
  MASS STORAGE (EXTERNAL)
  - MEDIA
  - CAPACITY
  - OTHER

  SOFTWARE

- RATIONALE – INSURE MAX UTILITY OF MODEL WITH MINIMUM MODIFICATION
- ALGORITHM IMPACT– NONE

WORKING GROUP I

CONTINUATION OF I/O EFFORT

- RECOMMENDATIONS

  CONTINUED EFFORT BY PAST GROUPS (ALONG PREVIOUS LINES).

  AVOID GETTING BOUND UP IN TERMINOLOGY TO THE DETRIMENT OF PROGRAMMING START-UP.

- RATIONALE

  CONTINUITY OF EFFORT

- IMPACT ON ALGORITHM

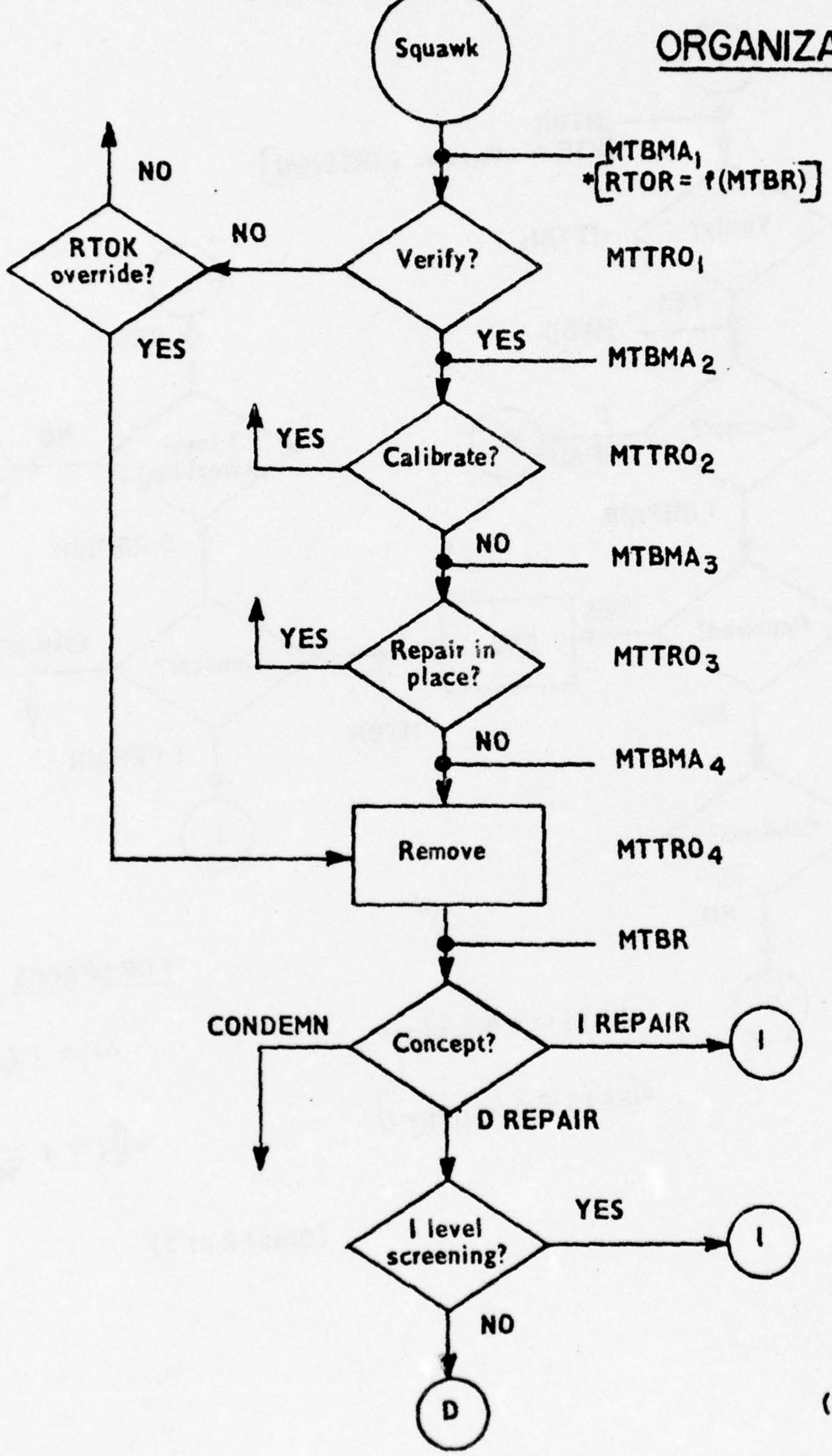
  UNKNOWN AT PRESENT

PROBLEMS WHICH ARISE TODAY WILL BE RESOLVED ASAP TO AID PROGRAMMING EFFORT.

3.2 WORKING PARTIES II AND III

MAINTENANCE FLOW DIAGRAM

ORGANIZATIONAL MAINT.



If only predicted MTBF's are available

Assume:

$MTBMA_1 = k_1\,(MTBF)$

$MTBMA_2 = k_2\,(MTBF)$

$MTBMA_3 = k_3\,(MTBF)$

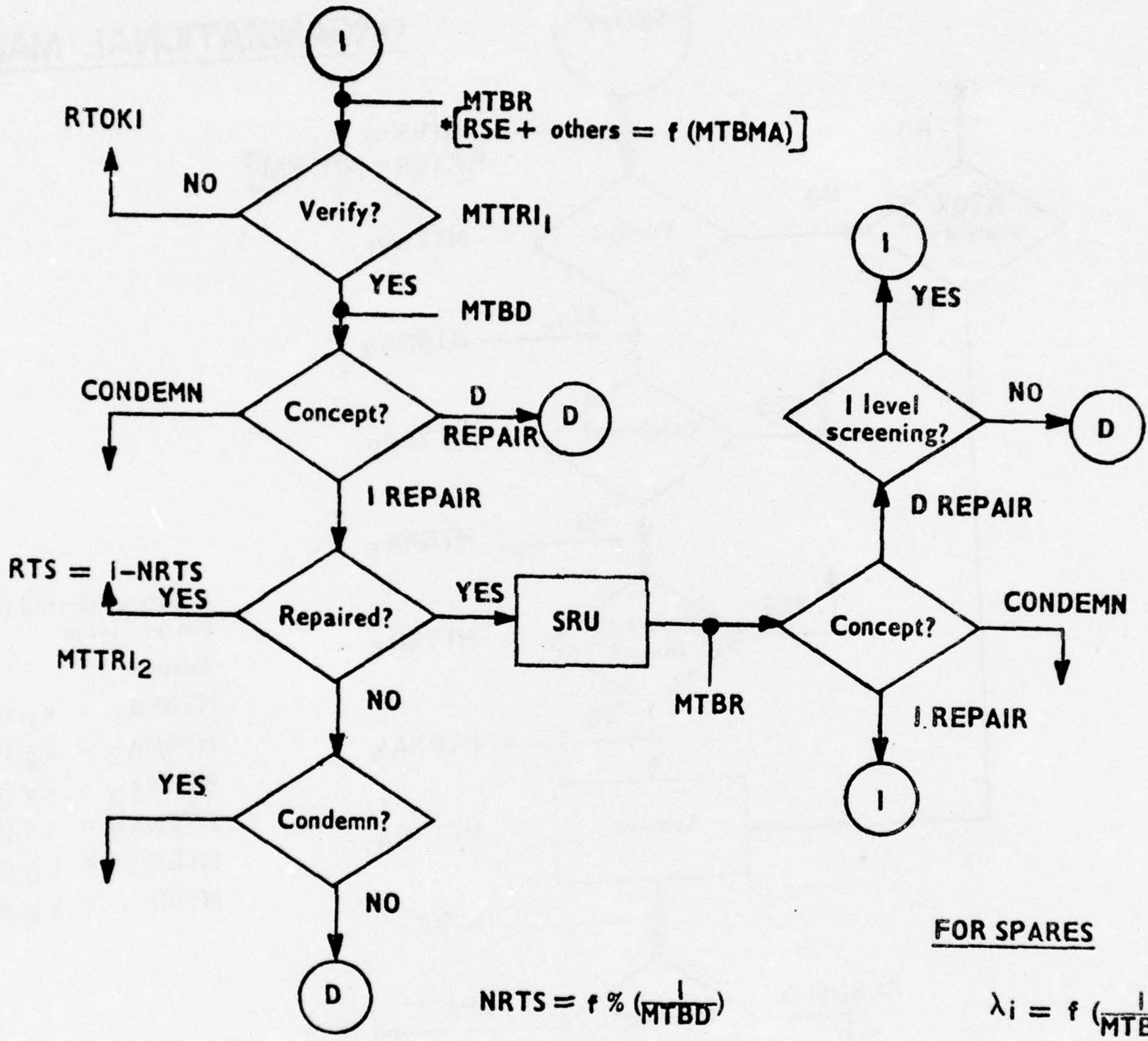
$MTBMA\,4 = k\,4\,(MTBF)$

$MTBR = k_5\,(MTBF)$

$MTBD = k_6\,(MTBF)$

(Sheet 1 of 3)

INTERMEDIATE MAINT.



$$NRTS = f\,\%\left(\frac{1}{MTBD}\right)$$

$$*\left[NRTS = f\,\%\left(\frac{1}{MTBF}\right)\right]$$

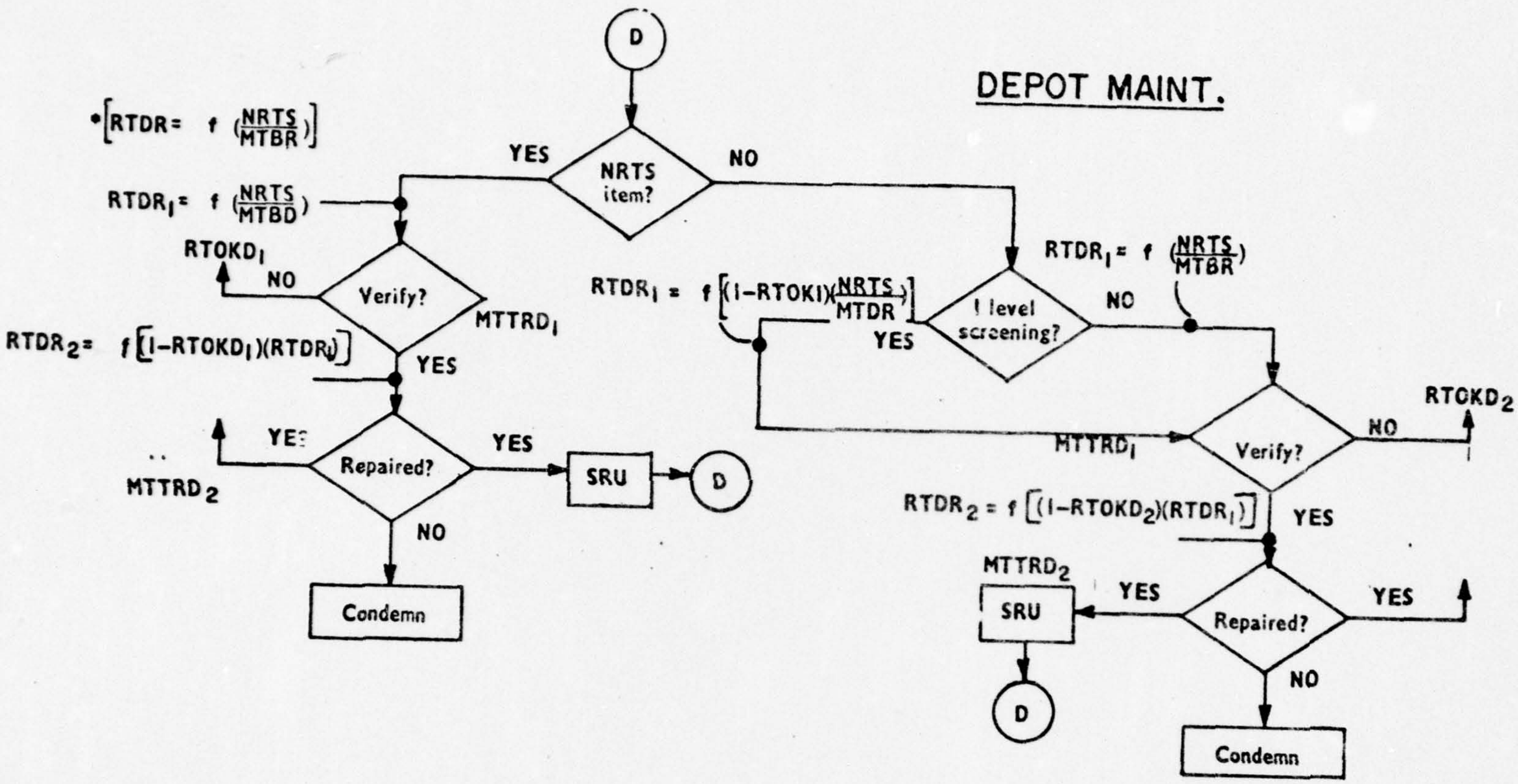
FOR SPARES

$$\lambda_i = f\left(\frac{1}{MTBD}\right)$$

$$*\left[\lambda_i = f\left(\frac{1}{MTBMA}\right)\right]$$

(Sheet 2 of 3)

DEPOT MAINT.



NOTES:

1. For Navy or commercial applications, set MTBD = MTBR since a removal will immediately impact supply.
2. Asterisked items indicate current algorithm or input definition affected.
3. NRTS factor does not reflect fixed concept items.
4. When exercising the model, it may be desirable to combine MTTRO's, MTTRI's, and MTTRD's and reflect at the highest respective frequency.

(Sheet 3 of 3)

3.3 WORKING PARTY IV

WARRANTY PROVISIONS

APPLICATION TO THE LIFE CYCLE COST MODEL

- WARRANTIES WILL NOT REQUIRE CHANGING THE EXISTING MODEL ALGORITHMS

  1. USER INPUTS
  2. PROGRAMMING TECHNIQUES

- THE USER MUST EVALUATE (BASED ON TYPE OF WARRANTY)
  - SPARES
  - DATA
  - AGE
  - INITIAL TRAINING
  - TRAINING EQUIPMENT
  - FIELD ENGINEERING
  - NEW FACILITY COSTS
  - ITEM MANAGEMENT COSTS

TERMS IN THE EQUATIONS ARE ADJUSTED TO WARRANTY TYPE. USE IMPROVED VALUES FOR MTBF, FOR THE YEAR OF WARRANTY EXPIRATION.

INTERNAL USE ONLY

WARRANTY PROVISIONS

O & M

- WARRANTY COST MAY BE INCLUDED IN THE HARDWARE ACQUISITION PRICE. (DEPENDING ON HOW SPECIFIED OR FUNDED)

- NORMALLY, WARRANTY COSTS ARE INCLUDED IN O & M.

- THE O & M EQUATION INCLUDES WARRANTY BY THE TERM

$$WE_{3ti} = (1 - TF) W_{3ti}$$

THE PROGRAM INPUTS WILL INCLUDE A MATRIX TO IDENTIFY TF (EITHER "1" OR "Ø") TO MAKE A PROGRAMMING DECISION TO COMPUTE THE EQUATION OR SKIP.

RATIONALE

1. Current factors do not relate to specific annual costs

2. Inclusion requires a complete new set of inputs:

3 Production Schedules
  Deployment Rate
  Site Activation Dates
  Etc

3. Inclusion would make the LCC model overly complex

4. If a Budget model is necessary, the inputs of (2) can be combined with LCC outputs in a separate program

4. INVITED PAPERS

This section contains the slides and (where available) the text of papers presented at the winter meeting of the Life Cycle Cost Task Group.

4.1 RELIABILITY IMPROVEMENT WARRANTIES

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2301 West 120th Street
Hawthorne, California

RELIABILITY IMPROVEMENT WARRANTIES

R I W

NORTHROP
Electronics Division

HISTORY OF WARRANTIES

UNIFORM SALES ACT OF 1906

- EXPRESSED WARRANTY
- IMPLIED WARRANTY

UNIFORM COMMERCIAL CODE (UCC)

- WARRANTY
- GUARANTEE

NORTHROP
Electronics Division

COMMERCIAL AIRLINE WARRANTY TYPES

1. STANDARD WARRANTY (FAILURE-FREE)
   - SPECIFIED NUMBER OF FLYING HOURS, OR CALENDAR TIME OR BOTH (1-3 YEARS)
   - VENDOR ASSUMES COST OF MATERIAL & LABOR TO REPAIR ALL FAILURES
2. ULTIMATE LIFE WARRANTY
   - APPLIES TO MAJOR STRUCTURE, BASED ON FLYING HOURS
3. RELIABILITY GUARANTEE
   - MUST DEMONSTRATE SPECIFIED MTBF OVER A STATED PERIOD
   - VENDOR PROVIDES SPARES, TECHNICAL ASSISTANCE, MOD KITS
4. MAXIMUM PARTS GUARANTEE
   - ESTABLISHES MAXIMUM MATERIALS COST PER FLIGHT HOUR (BRAKES, TIRES)

NORTHROP
Electronics Division

COMMERCIAL AIR CARRIERS STANDARD WARRANTY PROVISIONS

1. PERIOD OF COVERAGE
2. CONDITIONS - UNAUTHORIZED MODIFICATIONS
3. CONSEQUENTIAL DAMAGES
4. SCOPE - VENDOR REPAIRS OR REPLACES AT NO CHARGE
5. ASSIGNABILITY
6. SHIPPING COSTS
7. RETOK'S
8. DOCUMENTATION
9. ON-SITE REPAIR AUTHORIZATION

NORTHROP

COMMERCIAL AIR CARRIERS

RELIABILITY WARRANTY PROVISIONS

1. Specific Guarantees - MTBF, Material Cost, MMH/Flt.Hr.
2. Acceptance Conditions
3. Data Requirements
4. Spares
5. Consignment Spares
6. MTBF Calculation
7. Obligation Termination
8. Failure Definition

NORTHROP
Electronics Division

AIRLINE WARRANTY SUMMARY

USE - WIDESPREAD

PURPOSE - EXTEND VENDOR'S RESPONSIBILITY TO FIELD

TYPES - STANDARD (FFW), MTBF, MTBUR, MTL-COST

PERIOD - 3 - 5 YEARS

ADMINISTRATION - $15 - $30 PER CLAIM

AIRLINE VS. VENDOR MAINTENANCE - MOST AIRLINES DO THEIR OWN WITH REIMBURSEMENT FROM VENDOR

TURN-AROUND TIME - 5 - 30 DAYS

LOST CLAIMS - ATTEMPTING TO MINIMIZE

UNVERIFIED FAILURES - 20% - 80%, $50 - $200

DISPUTES - CAUSED BY INTERFACE PROBLEMS. GENERALLY NEGOTIATED

COST - 4% - 10% OF PURCHASE PRICE PER YEAR

NORTHROP
Electronics Division

NAVY WARRANTIES

1. LEAR SIEGLER, 2171-P GYROS
2. HONEYWELL - RADIO ALTIMETER - AN/APN 194
3. NORTHROP - OMEGA RECEIVER - AN/ARN 99V (1)
4. UNITED TELECONTROL ELECTRONICS - RADAR BEACON - APN 154
5. ABEX - HYDRAULIC PUMP - AP27V
6. RADAR ALTIMETER

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AIR FORCE WARRANTIES

1. Collins Radio & GE - TACAN, AN/ARN-106 (Study Contract)

2. Collins Radio - Flight Director System, FD-109

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CONSIDERATIONS IN MILITARY WARRANTIES

1. Contractor Acceptance - Varies
2. Pipeline Times - Normal Channels are Lengthy
   - Pending RFP's Specify 5 Days at Depot
3. Testing - May be Decreased
4. Data Requirements - Contract Management
   Warranty Evaluation
   Program Control
5. Funding - GAO Has Resolved Most of the Problems
6. Administration - Direct Interface Between User & Vendor

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RELIABILITY IMPROVEMENT WARRANTIES (RIW)

- Intended to be Similar to FFW or Standard Warranty
- Fixed Price Contract
- Vendor has Financial Incentive to Improve Reliability and Reduce Repair Costs
- Contractor Agrees to Repair or Replace, Within a Specified Turnaround Time, All Failures (Subject to Specific Exclusions, As Applicable).
- Not Intended For Routine Upkeep
- Does Not Cover Items that Wear Out Under Normal Use
- If the Warranty is a Part of the Acquisition Contract it Allows The Contractor to Incorporate R & M in the Initial Design.
- Contracted as a Separate Line Item

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DESIRED CHARACTERISTICS OF A WARRANTY

1. Price is Commensurate with Value
2. Moderate to High Initial Support Costs are Required
3. Readily Transportable
4. Self-Contained
5. Failures are Readily Identifiable
6. Operating Time and Use Environments Are Known
7. Can Be Contracted on Fixed Price Basis
8. Warranty Period Can Extend Over Several Years
9. Potential Reliability Growth & Repair Cost Reduction
10. A Warranty is Acceptable to Government & Contractor
11. Sufficient Quantity is Purchased for RIW to be Cost Effective
12. Design Discourages Unauthorized Field Repair
13. High Utilization
14. No-Cost ECP's Can Be Implemented
15. Failure & Use Data Will Be Available

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RIW PROVISIONS

RIW CONTRACTUAL PROVISIONS MUST BE TAILORED TO THE ITEM

THE FOLLOWING FACTORS SHOULD BE CONSIDERED:

1. TERM
2. OBJECTIVE/SCOPE
3. DEFINITION OF A FAILURE
4. EXCLUSIONS
5. SHIPPING COSTS
6. PRICE
7. MARKING
8. TURN AROUND TIME
9. RECORDS
10. SHIPPING CONTAINERS
11. NO-COST MODIFICATIONS
12. INSPECTION
13. DISPOSITION OF UNREPAIRABLE ITEMS
14. NOTIFICATION
15. UNVERIFIED FAILURES
16. ADJUSTMENTS
17. CONTRACTOR FURNISHED DATA/REPORTS
18. GOVERNMENT FURNISHED DATA

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RIW

BENEFITS TO THE GOVERNMENT

1. RESPONSIBILITY FOR FIELD RELIABILITY RESTS WITH THE CONTRACTOR RESULTING IN PRODUCT IMPROVEMENTS
2. GREATER EMPHASIS IS PLACED ON LCC
3. CONFIGURATION MANAGEMENT AND CONTROL IS EMPHASIZED
4. REPAIR TESTS ARE REDUCED
5. MINIMIZES INITIAL SUPPORT COSTS
6. IMPROVED WEAPON SYSTEM AVAILABILITY

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RIW

BENEFITS TO THE CONTRACTOR

1. INCREASED PROFIT POTENTIAL BY IMPROVING RELIABILITY (REDUCING RETURNS)
2. INCREASED PROFIT POTENTIAL BY REDUCING REPAIR COSTS
3. MULTI-YEAR GUARANTEED BUSINESS
4. KNOWLEDGE RELATING TO PRODUCT PERFORMANCE
5. PRODUCT IMPROVEMENTS PROVIDE POTENTIAL ADVANTAGES TO FUTURE BUSINESS

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CONCLUSIONS
RIW

- Value Has Been Proven .
- Current Military Procurements Emphasize Initial Acquisition.
- RIW Encourages Reliability Growth & Reduced Repair Times.
- Repair Facilities, AGE, Tech Manuals, Training & Spares are Correctly Identified to the Government Following the Warranty Period.
- Life Cycle Costs are Improved.
- Contractor Has A Greater Opportunity For Profit, Continuing Work Flow, Product Knowledge, and Often a Better Competitive Position.
- Warranty Contracts Must Be Carefully Written and Completely Understood by Both Parties.
- A Clear Definition of Exclusions and Use environments is Essential.
- Performance Characteristics Must be Quantified. The More Mature the Program, the More Accurate They Will Be.
- Warranty Period Must Be Long Enough For the Benefits of Product Improvement to be Realized.

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RIW PITFALLS

1. Disputes - Most Common Cause is Use Environments.
2. Administration is Added Expense.
3. Funding Problems - Currently Being Solved.
4. Retok's Can Be Sources of Dispute if Not Included.
5. Pipeline Time Can Be Greater Than Organic Repair Rotable Pools can be Established. Government Must Buy Sufficient Spare Quantities.
6. Government Experiences Reduced Self-Sufficiency.
7. Data Requirements Must Be Defined and Minimized.

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WARRANTIES FOR MILITARY AVIONICS PROCUREMENT

REVISION A

February 6, 1975

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NORTHROP ELECTRONICS

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ABSTRACT

The Department of Defense is directing the various military agencies to consider and, wherever applicable, solicit warranties of some type in procurement of electronic and avionic hardware. Only a few military agencies and military suppliers have had any actual experience with warranties. For such contracts to be mutually successful from both the military and industry viewpoint, each must be intimately familiar with the provisions and procedures associated with warranties.

This paper presents a brief history of warranties and discusses in some detail the experience that commercial airlines have had with warranties. The limited application to military programs is described and provisioning details of Reliability Improvement Warranty are explained.

WARRANTIES FOR MILITARY AVIONICS PROCUREMENT

INTRODUCTION

The paper is intended as a briefing for those who may not be familiar with warranty programs and provisions, particularly the Navy Failure Free Warranty (FFW) and the Air Force version of a similar program referred to as the Reliability Improvement Warranty (RIW).

Warranties have been used extensively by commercial air carriers for many years but have experienced only limited use by the Government. Recent direction has placed considerable emphasis on warranty provisions in Government contracting and, although such procurements are still considered experimental, it appears certain that future contracts will include warranties. The successful contractor must be not only willing to accept the provisions, but in their acceptance, be knowledgeable to assure profitability. Sufficient experience has been realized to establish, without doubt, that if the contractor is profitable, so is the military customer. Consequently, the risks must be defined and the contract provisions must be complete and understood by both organizations.

This presentation identifies risks and defines the contractual provisions by describing the history and types of both commercial and military warranties and explaining the basic details of the failure free and reliability improvement warranties.

THE HISTORY OF WARRANTIES:

The use of warranties began in the commercial world. The source of warranty law is the Uniform Sales Act of 1906:

> Expressed Warranty: "any affirmation of fact or any promise by the seller relating to the goods . . . if the natural tendency of such affirmation or promise is to induce the buyer to purchase the goods . . . and if the buyer purchases the goods relying thereon."
>
> Implied Warranty: "where there is a contract to sell or a sale of goods by description, there is an implied warranty that the goods shall correspond with the description . . .

The Uniform Sales Act has been superseded by the Uniform Commercial Code (UCC). The UCC is applied to Government contracts in that it represents the best legal interpretation and decision:

> Warranty: "that a warranty is an absolute undertaking or liability or the part of the warrantor, and the contract is void unless it is strictly and literally performed, . . . "
>
> Guaranty: "a guaranty is a promise, entirely collateral to the original contract, and not imposing any primary liability on the guarantor, but binding him to be answerable for failure or default . . . "

Warranties are, of course, offered to the general public on many commercial products. Most appliances carry some type of warranty and the provisions are usually displayed in some manner and often vary depending on the item and the manufacturer. The Uniform Commercial Code is the basis for the interpretation and administration of these warranties.

COMMERCIAL AIRLINE WARRANTIES

The commercial air carriers include a warranty provision of some type on virtually all of the equipment they purchase. The various types and provisions are discussed in detail.

TYPES:

There are four general types of airline warranties:

1. Standard Warranty (failure-free)
   All items will be free from defects in material, workmanship and design, conform to specifications, and will be suitable for the intended use.

   The warranty covers a specific number of flying hours, calendar time, or both. Typically 1 year -- up to 3 years, currently.

   The vendor absorbs all costs for material and labor to repair all failures during the warranty period.

2. Ultimate Life Warranty
   Applied to major structural components (wings, fuselage, landing gear), states components to be free of defects for a specified number of flying hours.

   Protection beyond the normal failure-free warranty period is provided, and claims are generally adjusted on a pro-rated basis consistant with usage.

3. Reliability Guarantee
   Specifies an MTBF, recognizing the infant mortality problem, requires the MTBF be demonstrated after an initial operating time period. The warranty period is in force until the MTBF has been demonstrated over a stated number of consecutive months.

   If the criteria is not met, the vendor must: (1) provide additional spares (2) provide technical assistance and/or mod kits and labor, until the specified MTBF is achieved.

4. Maximum Parts Cost Guarantee
   Establishes maximum material cost per flying hour for maintaining, modifying, repairing and overhauling the warranted items. Typical applications are tires and brakes. Reimbursement is made on either a 100% basis or a pro-rated basis between actual cost and guaranteed value. Typical time is 10 years.

PROVISIONS:

Typical warranty provisions include the following:

- o Period of coverage. - Calendar time or operating hours, whichever occurs first.
- o Conditions for maintaining coverage.- Warranty time Must be specified and not subject to unauthorized modification.
- o Consequential damages.- Vendor is Not responsible for consequential damages that may result from failure of the warranted device.
- o Scope of coverage.- Vendor agrees to repair or replace nonconforming item at no charge.
- o Assignability. - Warranty rights may be transferred to a third party if items are sold or transferred.
- o Shipping costs.- Buyer pays for shipping to the vendor. Vendor pays for return shipping.
- o No-Trouble-Found Reimbursement.- Buyer pays for shipping and testing of RETOK's. (Retests OK).
- o Documentation. - Data required is specified.
- o On-Site Repair Authorization.- If authorized by the vendor, the buyer may make repairs at his facility and invoice the seller for parts and labor based on agreed-upon rates. Sometimes on-aircraft remove/replace labor costs are included.

An MTBF warranty or Reliability Guarantee requires additional provisions to establish the basis for administration. The provisions include:

- o Specific Guarantees. - Defines MTBF, materials cost, man hours/flight hour, etc.
- o Acceptance Conditions. - Provides tolerances and time periods for compliance
- o Seller's Data Requirements. - Vendor provides system failure data.
- o Spares.- Buyer determines spares requirements based on specified MTBF.
- o Consignment Spares. - Additional spares are provided at no cost to the buyer if the observed MTBF is less than guaranteed MTBF. Additional spares are determined as follows:

$$n = NS \frac{G-A}{G}$$

Where:

n = number of additional spares
NS = total number of spares purchased to date
C = guaranteed MTBF
A = achieved MTBF

- MTBF Calculation. - Achieved MTBF is based on a monthly measurement corresponding to a 3 month moving average.

- Obligation Termination. - Vendor's obligation terminates when achieved MTBF exceeds guaranteed MTBF for 12 consecutive months. However, this period cannot occur earlier than the 25th month after system introduction.

- Definition of failure. - Establishes which failures are included in the MTBF calculation.

SUMMARY:

The commercial air carriers always seek warranties and few, if any, would consider purchasing equipment without some type of warranty. Vendor acceptance, on the other hand, varies because of the risk involved. There is a possibility of making additional profit, but, if not completely understood and properly negotiated, the warranty program could exhibit a sizeable loss for the vendor.

Commercial warranties are summarized as follows (See Table I)

APPRECIATION:

The trend is toward more extensive coverage. Although verbal agreements and "implied warranties" served well in the past, written precise agreements are now standard practice.

Purpose:
for Airline:
- extends QC effectiveness
- form of insurance
- improve reliability
- provide time to build maintenance capability

for Seller:
protection against catastrophic losses
- part of company support
- marketing tool
- control LCC
- obtain realistic hardware evaluation

TABLE 1

AIRLINE WARRANTY SUMMARY

APPLICATION - WIDESPREAD

PURPOSE - EXTEND'S VENDORS RESPONSIBILITY TO INCLUDE FIELD PERFORMANCE

TYPES - STANDARD (FFW), MTBF, MTBUR, M COST

PERIOD - 3-5 YEARS

ADMINISTRATION - $15 - $30 PER CLAIM

AIRLINE vs. VENDOR MAINTENANCE - MOST LARGE AIRLINES DO THEIR OWN MAINTENANCE WITH REIMBURSEMENT FROM THE VENDOR.

TURNAROUND TIME - 5 to 30 DAYS, EXCLUDING SHIPPING TIME.
2 to 3 WEEKS IS TYPICAL

LOST CLAIMS - ATTEMPTING TO MINIMIZE

AIRLINE WARRANTY SUMMARY
(cont'd)

UNVERIFIED FAILURES	RANGES FROM 20% to 80% COST OF RETOK TESTS RANGE FROM $50 to $200
DISPUTES	MAJOR CAUSE IS INTERFACE PROBLEMS. GENERALLY SETTLED THROUGH NEGOTIATION
COST	INCLUDED IN EQUIPMENT PURCHASE PRICE. RANGES FROM 4% - 10% PER YEAR.

CONDENSED FROM:

RADC-TR-73-249
"Use of Warranties for Defense Avionic Procurement
ARINC Research Corp.
June 1973

Types: The Standard FFW is most universal. MTBF is used and MTBUR is included. Difficult to administer cost guarantee because of data tracking and accounting problems. Other warranty types includes:

- dispatch reliability
- turnaround time
- turnaround time plus MTBF
- guaranteed spares availability
- equipment return/cost reimbursement for failure to meet MTBF goal
- maintainability guarantees

Period: Normally 3 years. If the equipment is proven, the airline prefers one year.

MTBF, MTBUR, cost warrantee contract term is usually 5 years with "infant mortality" provisions.

Administration: Cost to administer a warranty claim varies between airlines. The forms also vary. ATA has a committee addressing standardization of the claim forms.

Airline vs. Vendor Maintenance. Most vendors provide the airline with the option of performing their own maintenance, if they have an (approved capability). Rates for labor are negotiated, often with a stated maximum number of hours per module or unit. Vendor furnishes repair parts ($10/hr. is a common figure.)

Most airlines prefer to do their own maintenance although the labor rate may not cover all overhead. Reduction in turnaround time and spares levels offsets low labor rates. On complex equipment, the vendor performs maintenance until a capability is established in the airline repair shop. Sometimes airlines have union problems when vendors perform all maintenance.

On new equipment, vendors prefer to perform maintenance to observe failure patterns and perform failure analyses for product improvement, thereby reducing returns and warranty costs. Some vendors furnish field service support and world-wide service centers.

Turnaround Time: Turnaround time is often specified, it varies from 5 to 30 days, with the 5 day vendor utilizing a rotatable pool. A reasonable average is 2 weeks, not including shipping time. Additional spares are consigned based on:

$$N = R\,(t-T)$$

N - number of additional spares
R - 3 month moving average of units per day returned for repair
t - average TAT (3 month moving average)
T - Guaranteed TAT

Lost Claims: Claims are lost in the amount of $7-$8 million per year, because of record inadequacies, failure of maintenance personnel to follow standard procedures, and need for quick turnaround using in-house repair for which compensation does not exist.

Unverified Failures: Range from 20% to 80%, with 40% being a good average. One reason is that the FAA requires action if a complaint is registered. This often results in a remove and replace, particularly if a plane full of passengers is waiting.

To date BITE has not improved the RETOK.

Usually the vendor bills the airline for test costs. These costs range from $50 to $200 although $750 charges for an INS have been incurred. The Airlines pay for shipping and are trying to reduce RETOK's.

Disputes: Disputes are common. Interface problems are the most usual cause (probably more applicable to non-avionic equipment). Most disputes are negotiated. In cases where negotiation fails, the airline will appeal to the airframe contractor when he has overall warranty responsibility. Generally, disputes are not a serious problem. Airlines try to avoid "escape clauses."

Cost: The price of the equipment includes estimated future warranty repair and is dependent on MTBF. The warranty cost range is 4% - 10% per year of the basic unit purchase price. The lower percent applies to simpler units with proven MTBF's. The percentage generally applies to Standard FFW.

Generally, there are no major differences in warranty experience between large and small vendors and the considerations discussed above apply to the vast majority of avionics suppliers. The number of legal problems resulting in court actions from warranties appears to be negligible and the airlines do not require performance bonds.

MILITARY WARRANTIES

The regulations regarding warranties are covered in the Armed Services Procurement Regulation (ASPR) Paragraph 1.324. The regulation covers applications where the requirements are defined in general terms for the item rather than specific design details. The warranty is applicable only to correcting deficiencies found in the item at procurement and does not cover consequential damages. The Government has found it to be in their best interest to act as a self-insurer for liability of their high-value complex systems. The ASPR's also include a clause for action on disputes (ASPR 7-103.12), however, this often results in a lengthy resolution process.

Military warranties typically require the product to meet certain performance characteristics such as reliability. Unfortunately, there is a lack of precise standards, or commonalty of terms, to describe the various plans. Hughes Aircraft, in a warranty study (Airborne Exchange Equipment Lifetime Guarantee, RADC TR69-363, November 1969) described the following plans:

1. Full-Life guarantee plan. Allows any number of failures with the manufacturer responsible for repairs. This is also known as the Failure Free Warranty.

2. Maximum failure-rate guarantee plan. Allows a specified number of failures per unit time, above which the manufacturer becomes liable.

3. Failure-free guarantee plan. Does Not allow any failures, with the equipment guaranteed to be failure free for an extended period, subject to heavy penalties.

4. Other. Includes ASPR type of guarantee plan previously discussed. Normally only qualitative correction-of-deficiency statements are made.

MILITARY WARRANTY EXPERIENCE

NAVY - ASO

The Aviation Supply Office of the U.S. Navy, in Philadelphia was the first military organization to implement a failure free warranty. ASO had an FFW contract with Lear Siegler, Instrument Division for 800 2171-P Gyros used on the A-4 and F-4 aircraft. Lear Siegler was required to fix all failures for 1500 hours or 5 years, whichever came first. The fixed price contract was based on the number of failures and the cost per repair, where the number of failures was based on a field demonstrated mean-time-between-unscheduled removals (MTBUR) plus a 30% improvement (400 hours to 520 hours). The contractor actually achieved 523 hours.

The only exclusions to the warranty were units with broken seals and units with obvious physical damage. Damaged units required DCAS approval to be excluded from warranty. Unverified failures or re-test OK (RETOK) were not charged to the Government but were included in the repairs. RETOK's averaged 16-17%.

The reliability was established using the 3M system plus in-house repair data. All 800 units were controlled by serial number. Turnaround times were established as follows:

- o Removal to receipt at depot: 53 to 69 days
- o Ship to install time: 87 to 109 days
- o Repair turnaround time: 67 to 89 days.

Lear Siegler's contract required a facility turnaround time of 45 days, with a penalty of a day-for-day extension of the warranty period for all violations. Lear Siegler spent approximately 50,000 hours in laboratory reliability testing to improve their product. The Navy's major problem was in funding. Since O&M funds are available on an annual basis only, there were problems in funding a 5-year fixed price contract.

At present, both the Navy and Lear Siegler are pleased with the results. Both profited by the contract and it has been renegotiated for an additional 5-year period.

NAVY-NAVAIR

NAVAIR currently has two FFW contracts. One is a Radio Altimeter with Honeywell; the other is an Omega receiver with Northrop Electronics.

Minneapolis Honeywell is contracted to warrantee 24 AN/APN-194 Radio Altimeters for 1500 hours or 2 years, whichever comes first. Each unit costs the Navy \$4900 with the warranty, compared to the previous cost of \$4100 without warranty. The contractor is required to turn around all units within 45 days or be penalized 0.5% of the acquisition price for every day they are late. The procurement included all normal specs, reliability and maintainability demonstrations and standard configuration control procedures. The previous MTBUR of the unit was between 40 and 50 hours. The current MTBUR on the 24 units under warranty has been improved to approximately 700 hours. This is due, in part, to several no-cost ECP's submitted by Honeywell to improve reliability.

Northrop Electronics is contracted for a two year period to warrantee 95 AN/ARN99V(1) Omega Receivers. The maintenance philosophy is based on the concept of using BITE to fault isolate to the failed moduel which is returned to the contractor for repair. If the units do not fail, the Government is entitled to a price reduction. Northrop must document all repairs. The contractor pays for transportation both ways and is required to meet a 60-day turnaround within their plant. The penalty for lateness is 0.5% of the acquisition price per day, not to exceed 25% of the unit cost.

AIR FORCE - ASD

The F-111 AHRS was previously awarded to G.E. sole-source on a negotiated procurement basis. The SPO issued an RFP that included a warranty provision to 25 contractors, they received two responses; G.E. and Lear Siegler. In 1971, the Air Force issued a contract to Lear Siegler for 125 units at a cost of $6040 per unit plus $2200 for the 5 year warranty (7.3% per year). This award was 37% lower than the cost of the previous procurement due to a competitive contract. Lear Siegler used AFM 66-1 and in-house data to monitor contract performance. Each unit experienced an average of 26 flight hours per month with approximately 1.5 operating hours per flight hour. Lear Siegler improved their product reliability by incorporating two no-cost Class II ECP's.

AIR FORCE - ESD

The Air Force awarded study contracts to Collins Radio and G.E. to develop a solid state TACAN (AN/ARN 106). The development included a 2 year warranty plus a 3 year extension. The warranty provisions required the contractor to repair or replace, at his option; all failed units excluding loss or damage resulting from fire, flood, crash, enemy, etc., units with broken seals, or for special consequential or incidental damage to Government property. The contractor agreed to pay for all unverified failures (RETOK). The Government pays for shipping failed units to the contractor and the contractor pays for return shipment. The contractor is required to; meet a 30-day turnaround in his plant, keep records by unit serial number, and submit no-cost ECP's for product reliability improvement. The Government must test all units prior to return to the contractor and furnish failure data. The failed units are to be returned to the contractor within 60 days of failure, but the warranty is still valid if the units are not returned within days or failure data is not provided. All no-cost ECP's are automatically approved in 30 days unless the contractor is notified in writing. DCAS is to be notified concerning units that may not be in warranty and the Government will pay for the repair of non-warranty units.

The penalty for exceeding the turnaround period is a day-for-day extension of the warranty period. Lost or discarded units require an adjustment in contract price for the unused portion of the warranty. The contractor will prepare and submit bi-annual and annual reports for contract evaluation.

AIR FORCE - OCAMA

The Air Force included in the contract to Collins Radio for the FD-109 Flight Director system, a two year FFW provision plus a guaranteed Life Cycle Cost. The unit had an initial MTBF of 100 hours and the contract value was based on the contractor achieving an MTBF of 420 hours. There has been some improvement (250 hours) but there was a dispute over how MTBF was to be determined.

DISCUSSION

Contractor Acceptance of Warranties

Vendor enthusiasm for warranties ranges from poor to highly favorable, as expected. Most vendors would likely respond if a warranty provision was part of an RFP. The vendors that favor warranties feel that they would benefit by being provided with accurate user data for eventual product improvement. Those not favoring warranties felt that it was a marketing gimmick that might lessen their competitive posture. All vendors felt that the application of the hardware should be clearly defined for proper contract evaluation. Most vendors were opposed to permitting military maintenance on hardware covered by warranty for which they were liable for reimbursement. Some, however, felt that this would be acceptable under certain conditions.

Pipeline Times

Most repair contracts require the hardware to be shipped to the vendor's facility for repair. The failed unit follows normal supply channels using the controlling depot as the point of return. This often results in a transit time of 2 to 3 months requiring sufficient spares to fill the lengthy pipeline.

The Navy uses a program called "Closed Loop Aeronautical Management Program" (CLAMP) that allows for shipping directly from the using squadron to the vendor's facility. When a unit is identified for return, the message is sent to the vendor informing him of the action. He then ships a replacement unit from bonded stores, usually within 24 hours. The failed unit is received, repaired, and returned to the stockroom at the vendor's facility.

Proper shipping containers are essential to reduce or eliminate in-transit damage.

Testing

A general consensus of opinion is that, in a warranty program, testing may be decreased somewhat and the extensive documentation currently required could be reduced considerably.

Data Requirements

Data is necessary for contract management, warranty evaluation, and program control. Input information is furnished by both the Government andthe vendor. The Government data includes numerous Navy and Air Force reports including 3M, D057F, AFM 66-1, etc. The vendor provides in-house repair time, operating hours from an elapsed time meter, and failure analysis information. A combination of these inputs provides MTBF evaluation, operating hours to flight hours ratios, and classification of failures. The reporting periods include six-month, annual, and contract completion reports. They are normally computerized and vary with contract terms and conditions.

Funding Warranties

It is normally accepted that procurement funds be used for warranties on initial procurement and O&M funds be authorized for renewals. There has been some difficulty in the past using O&M funds since they can be allocated only on an annual basis. It is assumed that this problem has been worked by GAO. It is obviously better (or easier) to warranty items that have experienced service time since the warranty parameters are easier to define.

Warranty costs should be considered as a separate line item in the procurement contract so they can be clearly identified. The ASPR's are being considered for modification to clarify when a warranty should be used, and how it should be structured.

Warranty Administration

Most warranties create a direct interface between the user and the vendor. It is possible for a prime contractor to make warranty agreements with their subcontractors in a major weapon system procurement. The airlines often administer the warranties directly with the vendors even though the initial agreements were made by the aircraft manufacturers.

THE RELIABILITY IMPROVEMENT WARRANTY (RIW)

The RIW is also known as a Failure-Free Standard warranty. The objectives of an RIW are to provide an incentive to the vendor; to improve reliability, and reduce repair costs. It is not a maintenance contract to provide routine upkeep and does not cover items that are expected to wear out under normal use. The greatest value will be realized in the initial years of field deployment when related parameters are satisfactorily demonstrated. The Government may then accurately assess the cost effectiveness of continuing the warranty or assuming organic repair.

The RIW is a fixed price acquisition or overhaul contract where:

a) The contractor is provided with a financial incentive to improve reliability and maintainability.

b) The contractor agrees to repair or replace within a specified turnaround time, all failures (subject to specific exclusions, as applicable).

If the warranty is included in the acquisition of equipment it should be considered as a separate contract line item. A warranty provision at the time of acquisition provides incentive for the contractor to incorporate reliability and maintainability in the initial design.

WHAT TO WARRANTY

The selection of equipments as potential candidates for RIW coverage should include several of the following criteria:

1. The price of the warranty is commensurate with the contemplated value.
2. Moderate to high initial support costs are involved.
3. The equipment is readily transportable.
4. The equipment is generally self-contained.
5. Failures are readily identifiable
6. The expected operating time and use environments are known.
7. the equipment can be contracted on a fixed price basis.
8. The warranty period can be extended over several years or increments.
9. The equipment has a potential for reliability growth and reducting in repair costs.
10. Potential contractors indicate acceptance of an RIW provision.
11. A sufficient quantity is procured to make the RIW cost effective.
12. The equipment design discourages unauthorized field repairs and includes an elapsed time meter.
13. The equipment will be subject to high utilization.
14. The equipment will permit no-cost ECP's subsequent to Government approval.
15. Failure data and operational use data will be available to the vendor.

RIW FUNDING

Funding problems have been clarified by OASD (Comptroller) and the Office of Assistant General Counsel (FM). RIW shall be funded from the same appropriation as the acquisition or overhaul is funded.

RIW PROVISIONS

The RIW provisions must be tailored to the item, consequently a standard warranty clause is not feasible. The items that should be considered are:

1. Term. The length of warranty. Total operating hours or calendar time, or whichever occurs first.
2. Objective/Scope. To improve reliability and reduce repair costs. The reliability requirements should be clearly specified.
3. Failure. Define what constitutes a failure that will require the contractor to remove or replace, at his option, at no change in contract price.
4. Exclusions. State what conditions are not included in the warranty (Fire, crash, enemy, handling, packing, etc.).
5. Shipping Costs. State if the contractor or the Government pays for shipping failed units to the contractor and return of repaired units to the Government.
6. Price. Price warranty coverage as a separate line item.
7. Marking. Require the contractor to prominently mark that the unit is warranted, warranty period, and action to be taken upon failure.
8. Turnaround Time. Specify the turnaround time and any penalty/reward that may be associated with it. Turnaround time is defined as the time from receipt by the contractor to the date the repaired unit is shipped back to the Government from the contractor's facility.
9. Records. Describe the records that the Government will require the contractor to keep for each unit, by serial number, under warranty.
10. Shipping Containers. Indicate whether they will be Government or contractor furnished.
11. No-Cost Modifications. Indicate the procedure for the contractor to submit no-cost ECP's for product improvement. Indicate if Government approval will be automatic after a defined time period.
12. Inspection. State the extent of Government (DCAS) and contractor inspection requirements.
13. Disposition. The contractor shall dispose of each unit not considered repairable as directed by the ACO. Indicate the manner of disposition of unused warranty time for destroyed or lost units.
14. Notification. Indicate the requirement for the Government and the contractor to notify each other, within a specified time, of any deficiency discovered in a unit.
15. Unverified Failures. Is the contractor to be compensated for testing units under warranty where no discrepancy is found.

RIW PROVISIONS (Continued)

16. Adjustments. Indicate under what circumstances, if any, the Government is authorized to make adjustments to units under warranty.
17. Warranty Data. The contractor will establish and maintain a data system capable of providing a repair record of each unit, analyses of unit failure, number of items returned, turnaround time, pipeline time, remaining warranty coverage, etc.
18. Government Developed Data. The Government shall provide, in a timely manner, available operational and maintenance data generated on the equipment.

When to Warranty

The decision for using an RIW provision is usually based on a cost analysis to compare the contractor's RIW costs with the Government's estimate of maintaining the units themselves, plus the conventional method of incorporating reliability improvements. A proper analysis would compare the costs of a Government support organization doing the things a contractor would do under the RIW.

RIW Benefits

Many potential benefits may result from an RIW for both the Government and the Contractor.

The benefits to the Government include:

1. Responsibility for field reliability rests with the contractor resulting in improvements incorporated into the equipment.
2. Greater emphasis is placed on LCC.
3. Configuration management and control is emphasized.
4. Repair costs are reduced.
5. Minimizing initial support costs.

The Contractor benefits include:

1. Increase profit potential by improving reliability (reducing returns).
2. Increased profit potential by reducing repair costs.
3. Multi-year guaranteed business.
4. Knowledge relating to product performance.
5. Product improvements provide potential advantages for future business.

The RIW procurement results in reduced life cycle costs for the Government. The contractor is given a profit incentive to reduce repair costs and improve reliability beyond the normal initial hardware acquisition. The Government realizes improved hardware availability and reduced support costs.

CONCLUSIONS

The extensive experience with warranties by the airlines, and the limited military experience, definitely establish the value of warranty procurements. Current, standard military procurements do not emphasize field reliability but rather emphasize initial acquisition cost. This concept tends to put the contractor in a position of concentrating on unit cost without concerning himself with what happens to his equipment once it is delivered. Obviously, reliability and maintainability often suffer in this environment. It is even agreed that the contractor profits by lower reliability since spares and support equipment sales will be greater. In addition, if the military requires product improvements, he usually bears the cost of modifications. The airlines, on the other hand, have established standardization and interchangeability requirement that create a continuing competitive situation causing the contractors to be concerned with reliability and support costs. Further, all airline equipment is purchased with a warranty provision.

The military procurement process is extremely competitive in the R&D and acquisition phases, often with the low bidder getting all. Once the production contract is awarded, competition ends. The airlines procurements provide for continuing competition since, if one vendor's equipment proves to be unsatisfactory, they can buy another vendor's design and install it without aircraft modification. Further, the equipment performance is an important factor in future airline contracts. Thus, the contractor is motivated to produce superior products.

There is a vast difference between a controlled reliability test performed in a laboratory and that experienced through actual field use. More often than not, a contractor will pass a specified reliability demonstration, one way or another. Currently, the military attempts to provide reliability through these tests and financial incentives such as penalty provisions have been largely unsuccessful. The concept of encouraging reliability growth through warranties has been successful for the airlines. The contractor's profit depends on introducing product improvements to increase the MTBF. The warranty provides the contractor with the ability to closely monitor failure modes and trends so he is in an ideal position to develop the proper modifications to his equipment.

Maintainability benefits result in the same manner as reliability improvements. The contractor is motivated to reduce repair times and material costs to increase his profits. Shorter contractor repair times yield improved equipment availability to the military user.

The warranty period provides both the Government and the contractor an opportunity to closely identify repair facilities, repair equipment, tech manuals, training and spares requirements. All modifications to these disciplines are normally included as part of the warranty costs. Consequently, should the Government assume maintenance responsibility following the warranty period, these items are well defined and investment costs are minimized. Should the warranty period be extended, the Government has no initial support investment.

The warranty provides the Government with considerably improved life cycle cost control. Repair funds are defined on a fixed price basis, usually at a lower level than the anticipated cost of organic repair.

The contractor also stands to benefit from a warranty provision. He has the opportunity to gain profits by reducing the number of returns through introducing product improvements, usually with no-cost ECP's. He may also strive toward reducing repair costs by improving his internal procedures or his product's maintainability. To be sure, the additional profit potential is not without risks. The Navy/Lear Siegler gyro warranty contract, previously discussed, resulted in reduced Navy support costs and improved reliability.

Lear Siegler reported that the contract provided them with a very satisfactory profit. The contractor also benefits by being provided a continuing work flow, reliable information regarding his equipment's performance, and often a better competitive position for future procurements.

Warranty contracts need to be carefully written and completely understood by both the Government and the contractor. Normally the fewer exclusions, the fewer the disputes that arise. A clear definition of the exclusions is essential as is a clear understanding of the use environment. The warranty provision is only effective on those programs where the initial design is defined so that the performance characteristics can be quantified. Obviously, the more mature the program, the more accurate the characteristics will be. It is important that the warranty period be long enough for the benefits of product improvement to be incorporated and fully realized.

There are also problems that may arise associated with warranties:

1. Disputes often occur. These are minimized by provisions that are broad in coverage and by proper definition, as previously described. The most common cause for disputes is the use environments.

2. The administration of a warranty is an added expense if for no other reason than it represents a departure from normal practice. There may also be costs associated with having maintenance and supply personnel, documentation for warranty control and the adminstration of warranty contract disputes.

3. There are warranty funding problems because of the fixed price procurement covering an extended period of time. Recent experience indicates that these problems are being overcome.

4. Unverified failures present a problem if they are not included in the warranty provision.

5. The pipeline time with a warranty provision is often greater than it is when the Government repairs their own equipment. The time to return a unit to a vendor is often greater than the time from removal on the flightline to an intermediate level repair shop where the maintenance is performed. Several procedural policies can be adopted to minimize this problem. Guaranteed turnaround times are often specified or the contractor can maintain a pool of rotable spares purchased by the military.

6. The military will experience reduced self-sufficiency if they rely on the contractor for repairs. The possibility of contractor strikes, bankruptcy or natural disaster may have to be considered. Often key military personnel are trained by the contractor duing the warranty period to minimize this effect.

7. Fairly extensive reporting and analysis requirements are often proposed. It may be possible to tailor current data requirements to reduce the details necessary for warranty evaluation.

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3. Proceedings of Failure Free Warranty Seminar, Oscar Markowitz, et al, Technical Division, Avionics Supply Office, December 12, 13, 1973.

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4.2 REPAIR RELIABILITY BASED ON TOTAL COST CONSIDERATIONS

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Dynamics Research Corporation
50-60 Concord Street
Wilmington, Massachusetts

REPAIR RELIABILITY
BASED ON
TOTAL COST CONSIDERATIONS

by

Russell B. Stauffer
TIRAS Department Manager
Dynamics Research Corporation

INTRODUCTION

This paper describes an application in which concerns over Life Cycle Costs were used as the basis for determining the required field reliability (following repair) of an inertial instrument type to make repair more cost-effective than replacement with a new instrument.

We will discuss (Figure 1) some of the background that led us to pursue this procedure and then examine its application under both single and multi-level repair modes, finally coming to some conclusions about its effectiveness. In the course of the discussion, we will utilize some apparently complicated algebraic expressions. We will not go into the time consuming task of deriving them here; however, we have made them an Appendix to this paper in the formal Proceedings.

SUMMARY

- LIFE CYCLE COST APPLICATION
- BACKGROUND
- SINGLE LEVEL CASE
- MULTI LEVEL CASE
- CONCLUSIONS

1.

It should be noted that this is an inverted use of Life Cycle Costing (Figure 2). Normally one is concerned with finding the cost of meeting certain objectives. Here our concerns are with establishing objectives which will enable us to hold to a reasonable Life Cycle Cost.

This effort came about (Figure 3) as the result of some reliability studies made by Dynamics Research Corporation (DRC) on the inertial components in a particular operational guidance system. At the time the work was initiated we had many thousands of hours of field operating experience on which to base reliability calculations. The instruments which could be shown statistically to have significantly different reliability characteristics. Both groups met overall system reliability requirements but the reliability of new instruments (MTBR) was more than three time the reliability of the repairs.

The question (Figure 4) was then: "Does it make sense, from the viewpoint of cost, to repair instruments or should we make them a throwaway item?" and if we do repair them, how good must they be so that, over some life cycle, the total cost of repairs will be less than the cost of using replacement instruments?

This latter question is illustrated schematically in Figure 5. If the population consists entirely of new instruments which fail at a constant rate then the number of replacements (and the cost of replacement) will be linear with time. If, on the other hand, we mix into the population repaired instruments which fail at a

APPLICATION

NORMAL

OBJECTIVES → COST

INVERTED

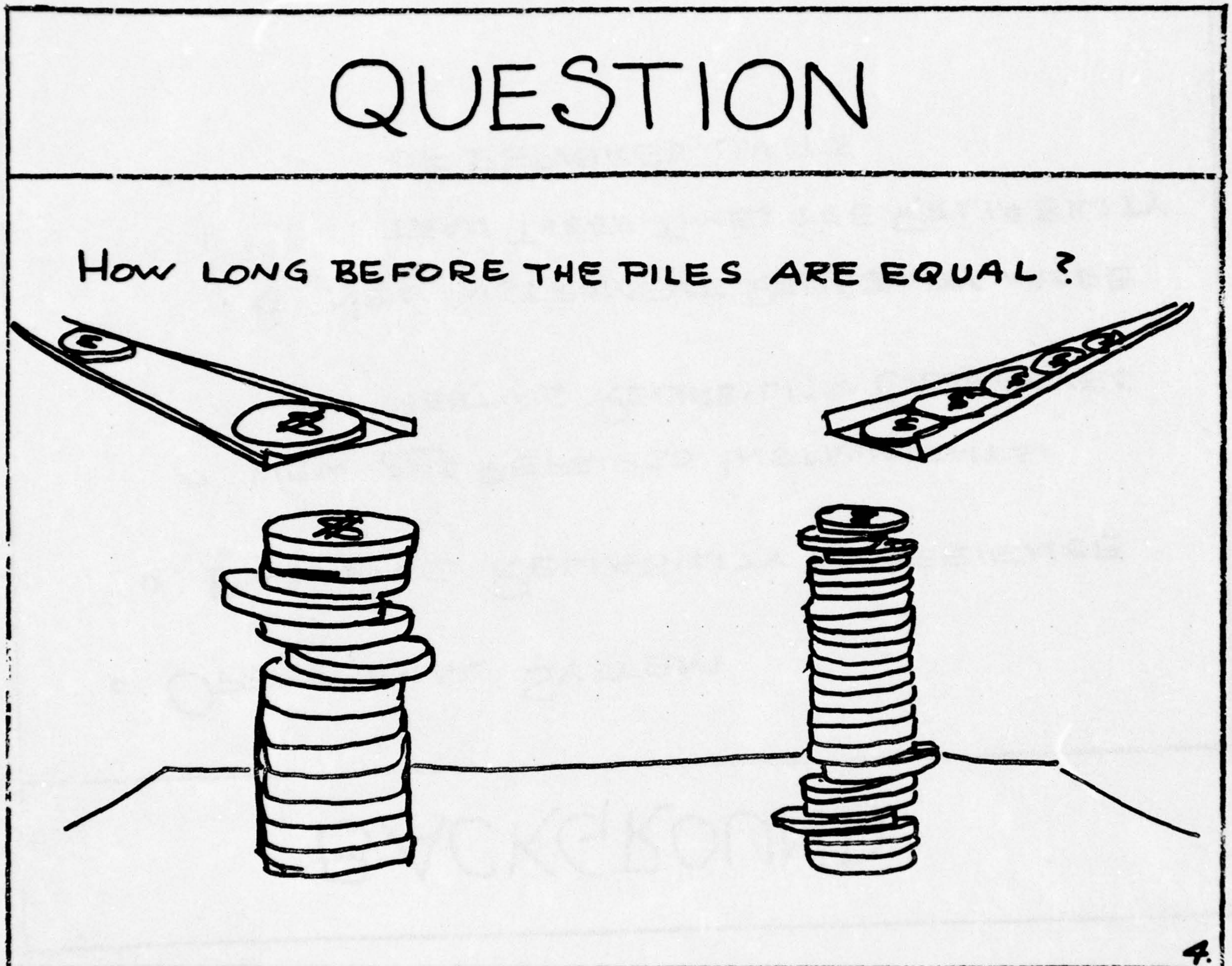
COST → OBJECTIVES

2

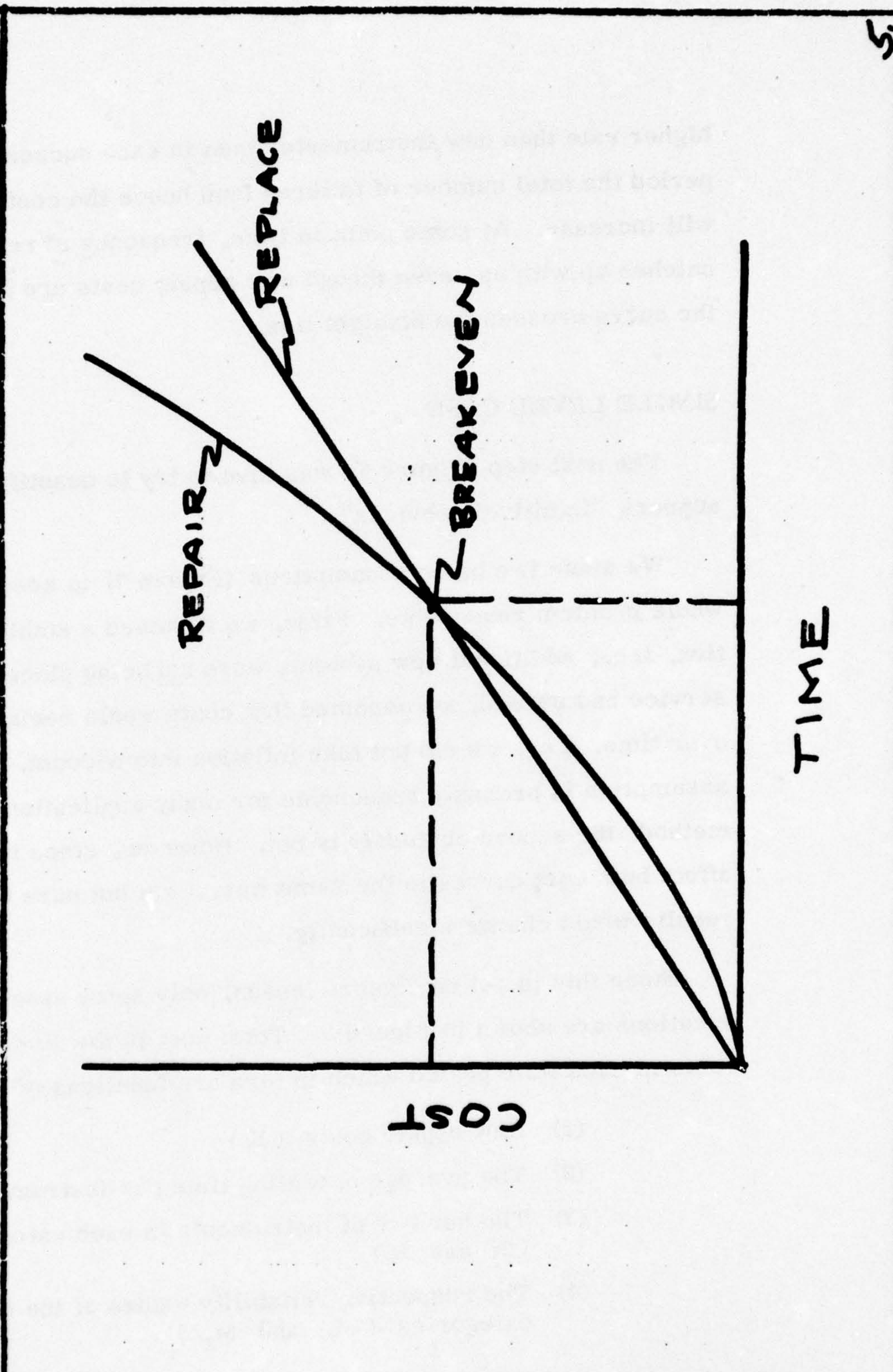
BACKGROUND

- OPERATIONAL SYSTEM
  - EXTENSIVE RELIABILITY EXPERIENCE
    - NEW <u>AND</u> REPAIRED INSTRUMENTS MEETING RELIABILITY OBJECTIVES
      - NEW INSTRUMENT RELIABILITY MORE THAN THREE TIMES THE RELIABILITY OF REPAIRED UNITS

5.


QUESTION
HOW LONG BEFORE THE PILES ARE EQUAL?
4.

RATIONALE



higher rate than new instruments, then in each succeeding time period the total number of failures (and hence the cost of repairs) will increase. At some point in time, frequency of repair catches up with us, even though unit repair costs are lower and the curve crosses the straight line.

SINGLE LEVEL CASE

The next step (Figure 6) was then to try to quantify what appears "intuitively obvious".

We made two basic assumptions (Figure 7) to keep the whole problem reasonable. First, we assumed a stable population, i.e., additional new systems were <u>not</u> being placed into service and second, we assumed that costs would remain constant over time, i.e., we did not take inflation into account. The first assumption is probably reasonable for many applications of the method, the second obviously is not. However, since it would affect both cost curves in the same way, I am not sure that the results would change significantly.

Since this is not an algebra lesson, only some essential equations are shown in Figure 8. Total cost is the sum of the costs in each time period which in turn are functions of:

(1) Unit repair costs (K)

(2) The average operating time per instrument (T)

(3) The number of instruments in each category (N and R)

(4) The respective reliability values of the two categories (M_n and M_r) .

SINGLE LEVEL CASE

- ASSUMPTIONS
- EQUATIONS
- RESULTS

6.

ASSUMPTIONS

- Constant Population
- Constant Costs

7

EQUATION

$$C_T = \sum_{i=1}^{n} KT\left[\frac{N_i}{M_n} + \frac{R_i}{M_r}\right]$$

with:

$$R_i = P - N_i$$

$$N_i = N_{i-1}\left(1 - \frac{T}{M_n}\right)$$

and substituting:

$$p = \left(1 - \frac{T}{M_n}\right)$$

$$M = \left(\frac{1}{M_n} - \frac{1}{M_r}\right)$$

the equation becomes:

$$\text{(Repair)}\quad C_T = KT\left\{M\left[\frac{N_0 p(1-p^n)}{1-p}\right] + \left[\frac{nP}{M_r}\right]\right\}$$

$$\text{(Replace)}\quad C_T = KT\left[\frac{nP}{M_n}\right] \quad (\text{since } M_r = M_n)$$

8.

After some algebraic substitutions and manipulations to get rid of the summation signs we end up with the final form of the equation. The term with N_o is the summation of N_i ; M contains both M_n and M_r . If we split the first term into its two components and then combine the second part with the last term, we get back to the original equation.

With this equation reduced to a simple FORTRAN statement we need only the inputs from Figure 9. Note that the equation also holds for the "always replace" option since then, $M_r = M_n$, M goes to zero and the first term drops out. (Of course, different values of K must be used.) In the case we were working, the first four inputs were well established but M_n and M_r were subject to some uncertainties. Therefore, we decided to evaluate the equations and plot the results rather than go to a multiplicity of direct analytic solutions.

Figure 10 is one of those plots and looks as one would expect.

The results are easier to use, however, if the data are replotted as shown in Figure 11. In this version, we can select the curve that most nearly represents the reliability of new instruments, select a desired pay-back period and then read the necessary "repair reliability" directly off the scale.

MULTI-LEVEL CASE

We looked next (Figure 12) at a situation where two levels of repairs (minor and major) were involved.

UTILIZATION

INPUTS

P = Number of units in population

N_o = Number of NEW units in population at start

T = Operating hours per month per unit

K = Repair Cost per unit

M_n = MTBR of new units

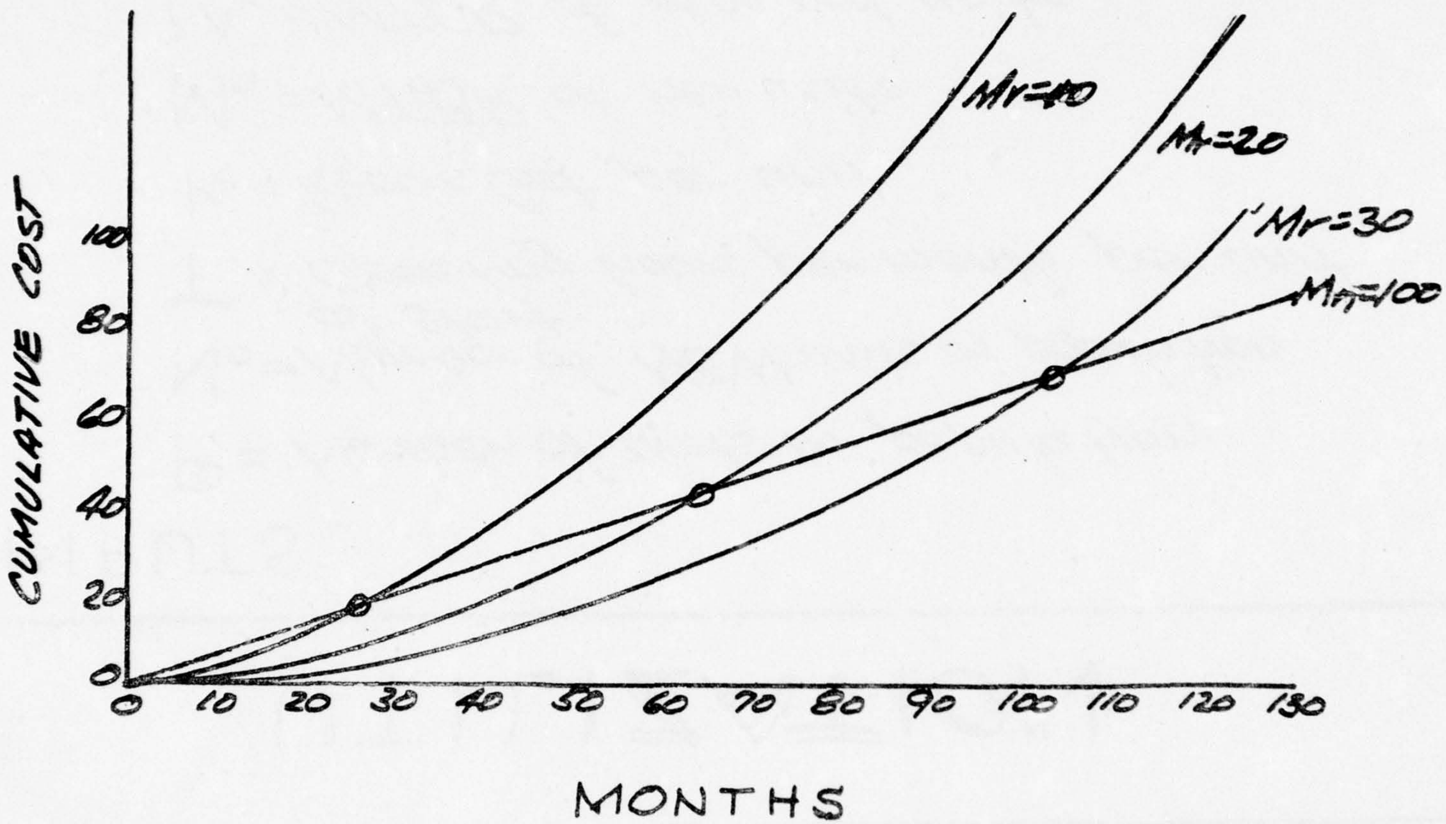
M_r = MTBR of repaired units

OBJECTIVE

Find breakeven point for various M_r

9.

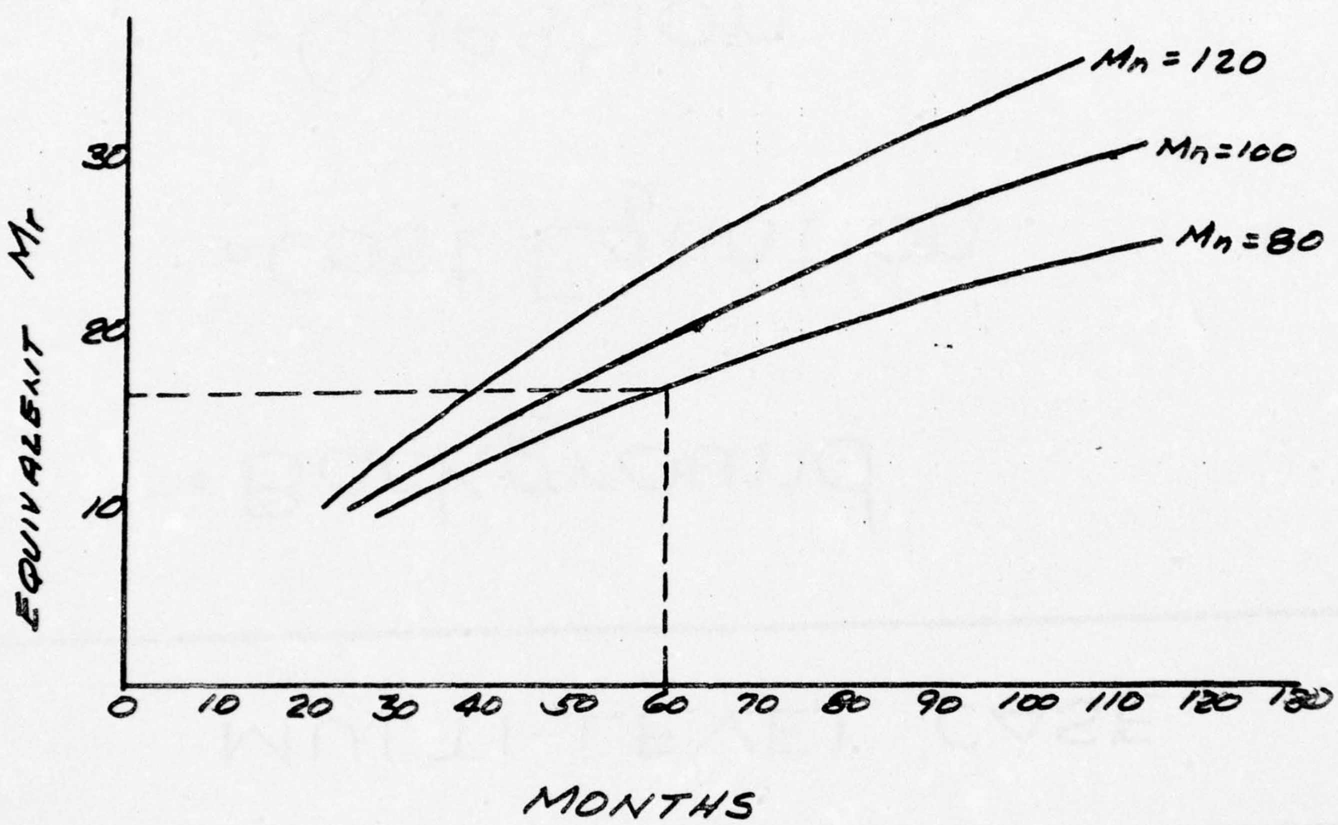
RESULTS



Mr=10
Mr=20
Mr=30
Mr=100
CUMULATIVE COST
0
20
40
60
80
100
0
10
20
30
40
50
60
70
80
90
100
110
120
130
MONTHS

10

USE OF RESULTS



11

MULTI-LEVEL CASE

- Background
- Cost Equation
- Question

12

By way of background (Figure 13) the evidence showed that a large fraction of the repairs were of such a nature that critical sub-assemblies had to be returned to the vendor for repair. It was also a fact that even vendor-repaired sub-assemblies were not as reliable as newly manufactured assemblies.

Taking these facts into account, the cost equation looks like this (Figure 14). We now have two subsets of repairs each with their individual repair costs and three different failure rates (including the failure rate for new units). I think the resemblance of this equation to the previous one is apparent since the same kind of substitutions and transformations were made. M_1 and M_2 result from combining reliability terms, we have the summation term for N_i and R which is the combined cost term.

The question we asked ourselves (Figure 15) was how much better new units had to be than repaired ones to justify the additional cost.

This time we elected to go to the analytical solution (Figure 16). We simply took the multi-level equation, equated it to the single level form (with the appropriate cost and reliability inputs) and solved for M_{rn} . The resulting equation has too many terms to display here and there is no real way to combine them. However, it is simple algebraic form and hence can readily be written as a FORTRAN statement.

BACKGROUND

- Large fraction of repairs are beyond the repair capability of the Government SRA
- Critical sub-assembly is returned to vendor for repair

13

COST EQUATION

$$C_T = (aK_1 + bK_2)\sum_{i=1}^{n} F_i \qquad a+b \equiv 1$$

where $F_i = (F_{n_i} + F_{rc_i} + F_{rn_i})$ $\qquad F(\,)_i = \frac{TQ(\,)_i}{M(\,)}$

Substituting:

$$M_1 = \frac{1}{M_n} - \frac{a}{M_{rc}} - \frac{b}{M_{rn}} \qquad M_2 = \frac{a}{M_{rc}} + \frac{b}{M_{rn}}$$

$$R = aK_1 + bK_2 \qquad p = 1 - \frac{I}{M_n}$$

the equation becomes:

$$C_T = RT\left\{M_1\left[\frac{N_0 p\,(1-p^n)}{1-p}\right] + M_2\left[nP\right]\right\}$$

14

QUESTION

How much better must M_{rn} be than M_{rc} to justify

$$K_1 > K_2$$

15

SOLUTION

Single-Level Equation

$$C_T = KT\left\{M\left[\frac{N_o p(1-p^n)}{1-p}\right] + \frac{nP}{M_r}\right\} \qquad (1)$$

Multi-Level Equation

$$C_T = RT\left\{M_1\left[\frac{N_o p(1-p^n)}{1-p}\right] + M_2[nP]\right\} \qquad (2)$$

Note that "K" & "R" are cost terms
"M," "M_1" & "M_2" are reliability terms

$\therefore$ *Equate (1) and (2)*
Solve for Mrn to get "Breakeven" value

16

For a typical case (Figure 17) the results look like this. Of interest is the asympototic portion of the curve which indicates that there is a minimum point in time below which M_{rn} can never be high enough to justify the extra cost. When you evaluate the equation, this shows up as a negative M_{rn} . Although not shown on the chart, we also demonstrated that the curves are relatively insensitive to $\pm$ 20% changes in M_n .

In conclusion (Figure 18), I would like to suggest the following:

1. An analytic expression relating reliability and cost is not particularly difficult to develop.

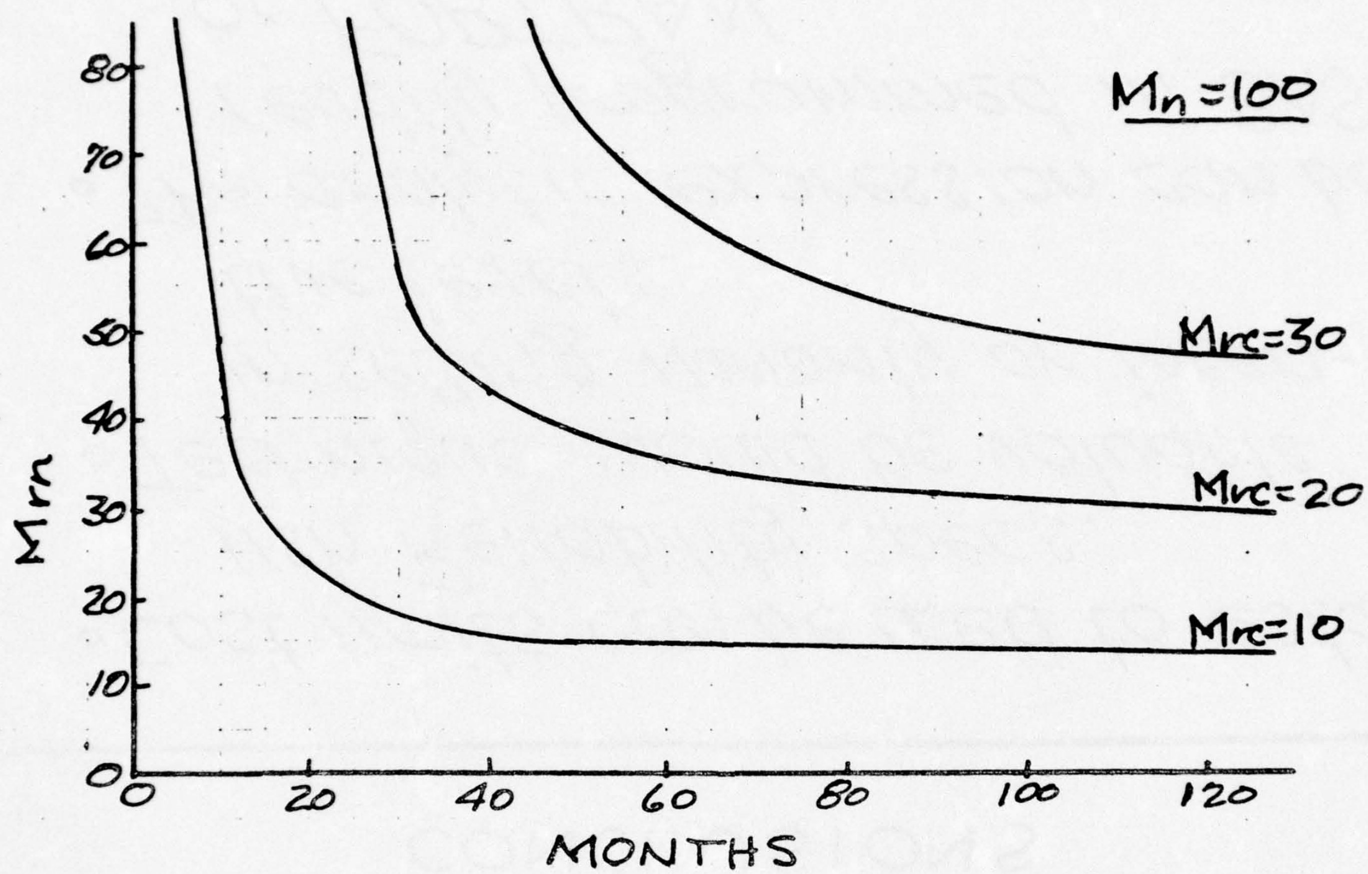
2. The resulting equation can be easily programmed in FORTRAN or in BASIC on a time-sharing system.

3. Outputs must be tested however, for sensitivity and practical reality.

4. The technique forms the basis of setting reliability requirements to meet cost goals.

5. The procedure might also be used in establishing warranty provisions or incentive levels.

RESULTS



Mn=100
Mrc=30
Mrc=20
Mrc=10
Mrn
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
MONTHS

17

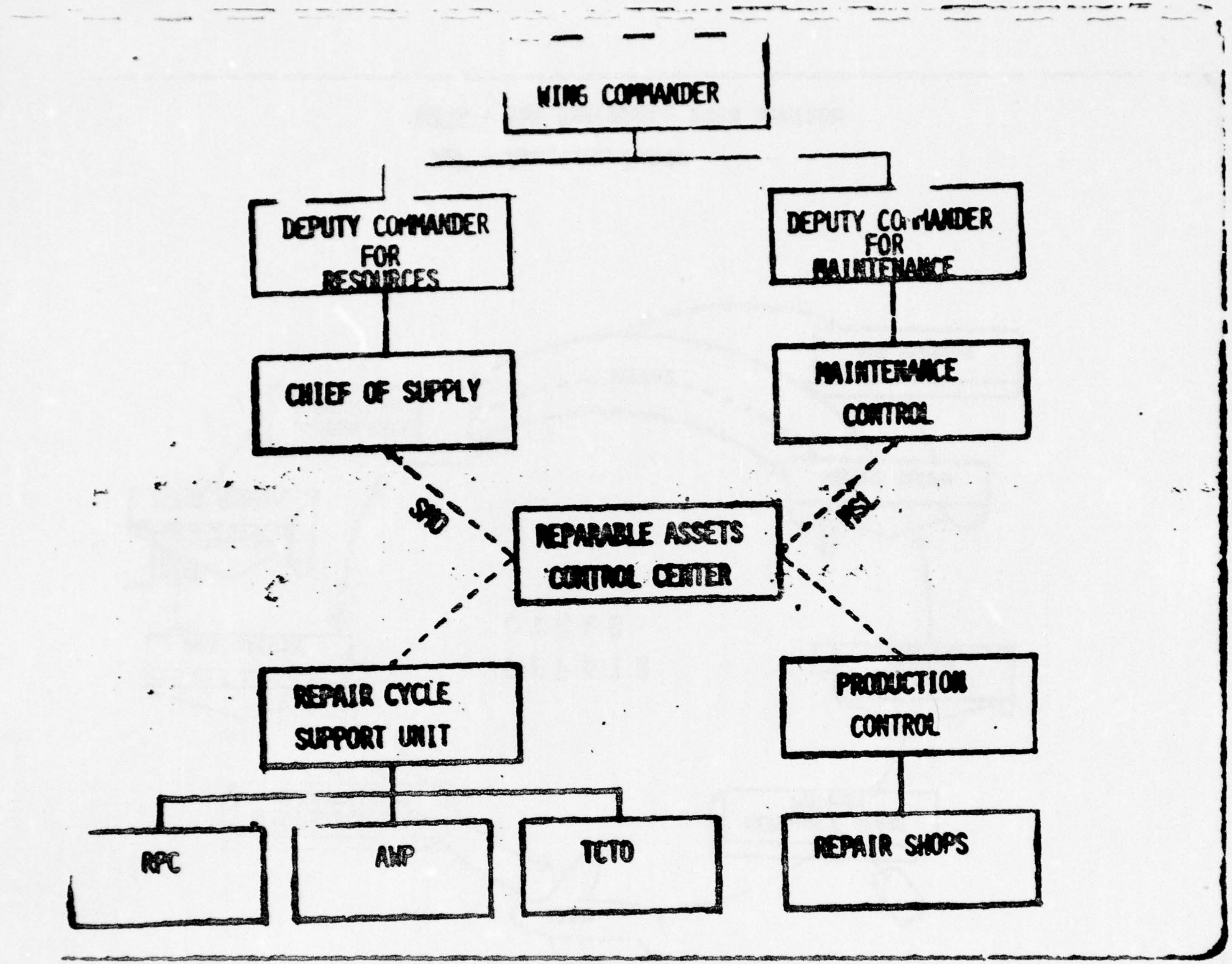
CONCLUSIONS

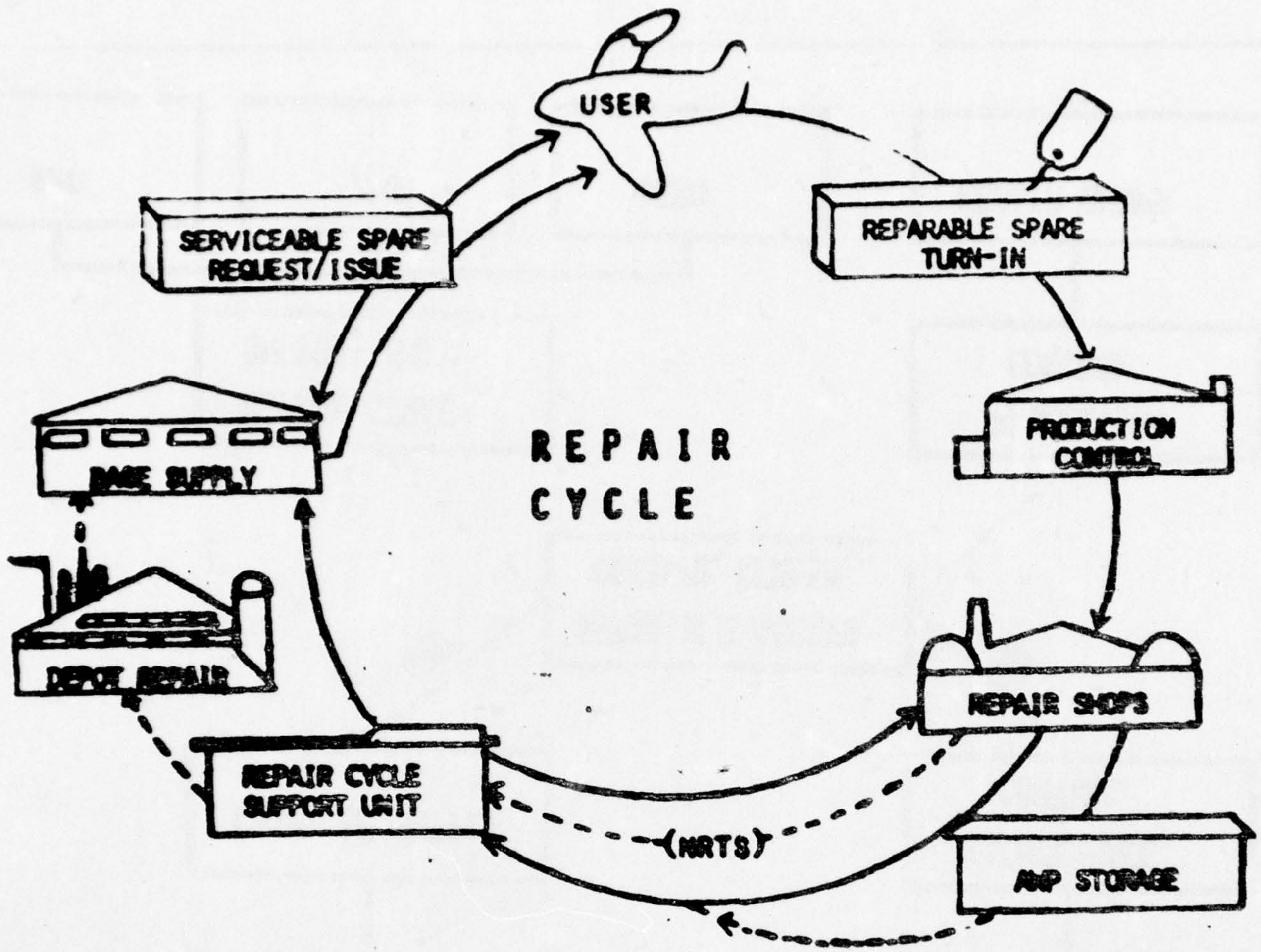
- Cost limits can be used to establish Reliability specs.
- Technique would be valuable in setting warranty or incentive levels.
- The analytic expression can be readily programmed in BASIC or FORTRAN
- Outputs should be tested for sensitivity

4.3 BASE LEVEL SUPPLY AND MAINTENANCE ACTIVITIES

Col. Harry Brewer - DCM
Lt. Col. James Turner - CS

MacDill Air Force Base
Florida


WING COMMANDER
DEPUTY COMMANDER FOR RESOURCES
DEPUTY COMMANDER FOR MAINTENANCE
CHIEF OF SUPPLY
MAINTENANCE CONTROL
REPARABLE ASSETS CONTROL CENTER
REPAIR CYCLE SUPPORT UNIT
PRODUCTION CONTROL
RPC
AWP
TCTO
REPAIR SHOPS



AWP - AWAITING PARTS

NRTS - NOT REPARABLE THIS STATION

RESOURCES/PRODUCTION

- **RESOURCES**
  - AVG STRENGTH
    - AMS - 254
    - OMS - 372
    - FMS - 446
    - MMS - 495
    - 1567
  - ACFT POSSESSED
    - 69.3

- **PRODUCTION**
  - AVG MONTH
    - SORTIES - 1263
    - FLY HRS - 1759
    - SORTIES/DAY - 58
    - SORTIE LENGTH - 1.4
    - ITEMS REPAIRED - 1988

SUPPLY RESOURCES

$ 11 MILLION INVENTORY

$ 7.8 MILLION ANNUAL BUDGET

$ 58 MILLION EQUIPMENT

305 PEOPLE

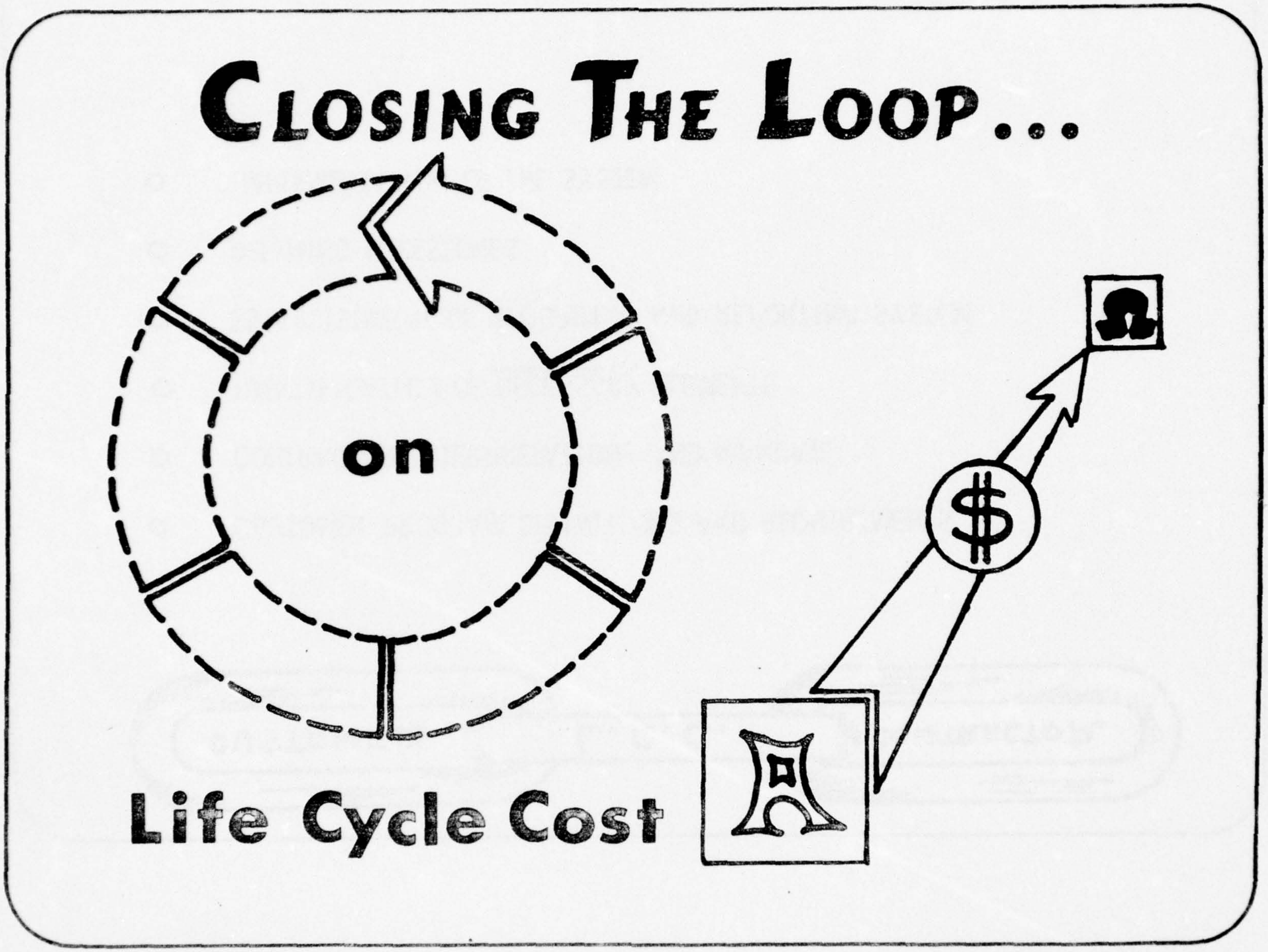
30 TRUCKS

RADIO & TELEPHONE NETWORK

UNIVAC 1050-II DIGITAL COMPUTER

4.4 CLOSING THE LOOP ON LIFE CYCLE COST

Mr. Frank Merlino
Northrop Electronics
2301 West 120th Street
Hawthorne, California



NORTHROP
ELECTRONICS DIVISION

- CUSTOMER PROGRAM DEFINITIONS AND REQUIREMENTS
- CONTRACTOR INTERPRETATIONS AND MANDATE
- IDENTIFICATION OF NECESSARY ELEMENTS
- ESTABLISHMENT OF RECORDING AND REPORTING SYSTEM
- DEFINING MILESTONES
- IMPLEMENTATION OF THE SYSTEM

NORTHROP
ELECTRONICS DIVISION

CUSTOMER - program definitions and requirements

Veracious or Visionary

- THE OPERATIONAL CONCEPT
- THE MAINTENANCE CONCEPT
- VALIDITY OF THE HISTORICAL MODELS
  - OPERATIONS
  - SUPPORT COSTS
- EXAMINING THE R.O.C.
- QUALIFYING THE RFP/RFQ

NORTHROP
ELECTRONICS DIVISION

CONTRACTOR - interpretations and mandate

Fidelity versus Fantasy

- THE ELUSIVE HARDWARE CONSTANCY CONCEPT
- SUPPORT EQUIPMENT RATIONALE
- SPARES DEFINITION METHODOLOGY
- TRAINING REQUIREMENTS
- DATA - "A BUSHEL OR A PECK"
- VALUE ENGINEERING ANALYSES

NORTHROP
ELECTRONICS DIVISION

ELEMENT IDENTIFICATION...

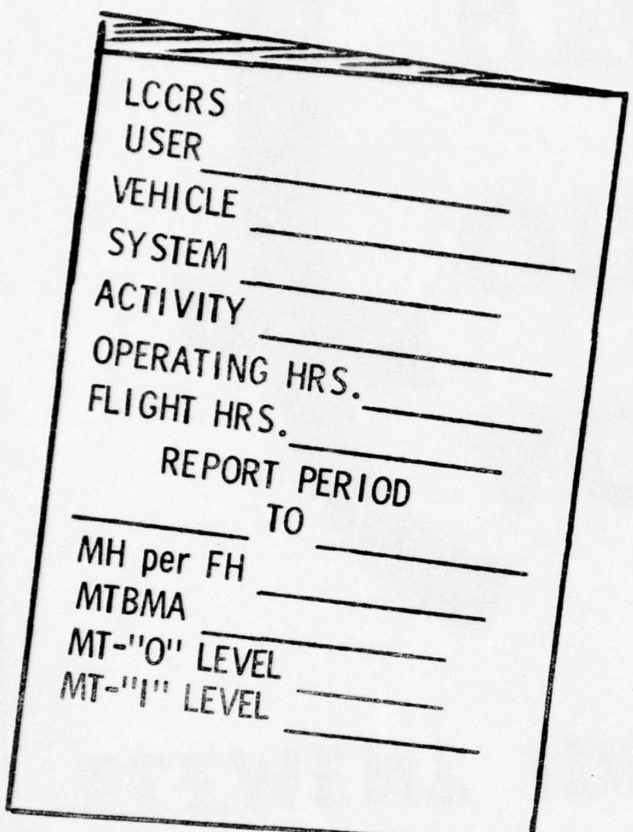
fACTS ?

fORM ?

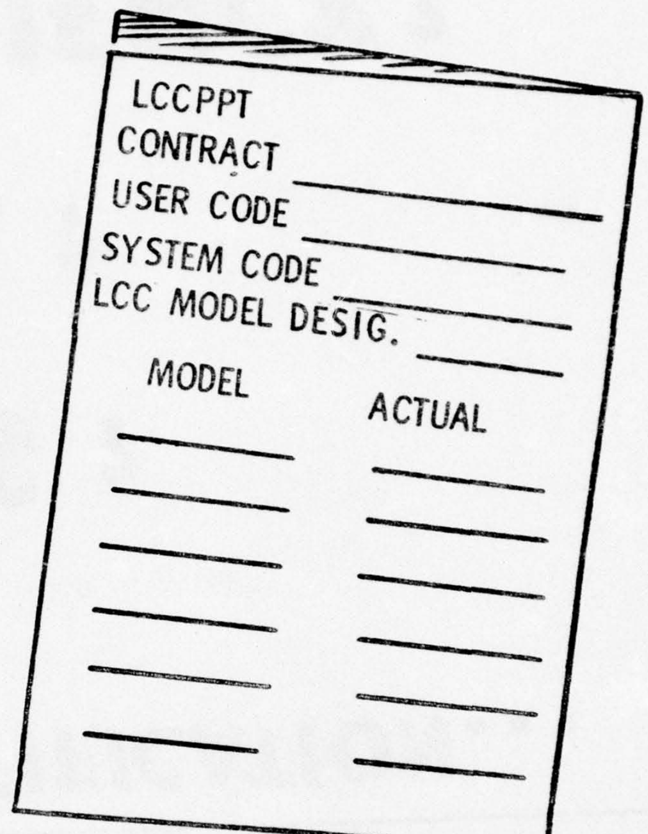
fREQUENCY ?

NORTHROP
ELECTRONICS DIVISION

RECORDING.....



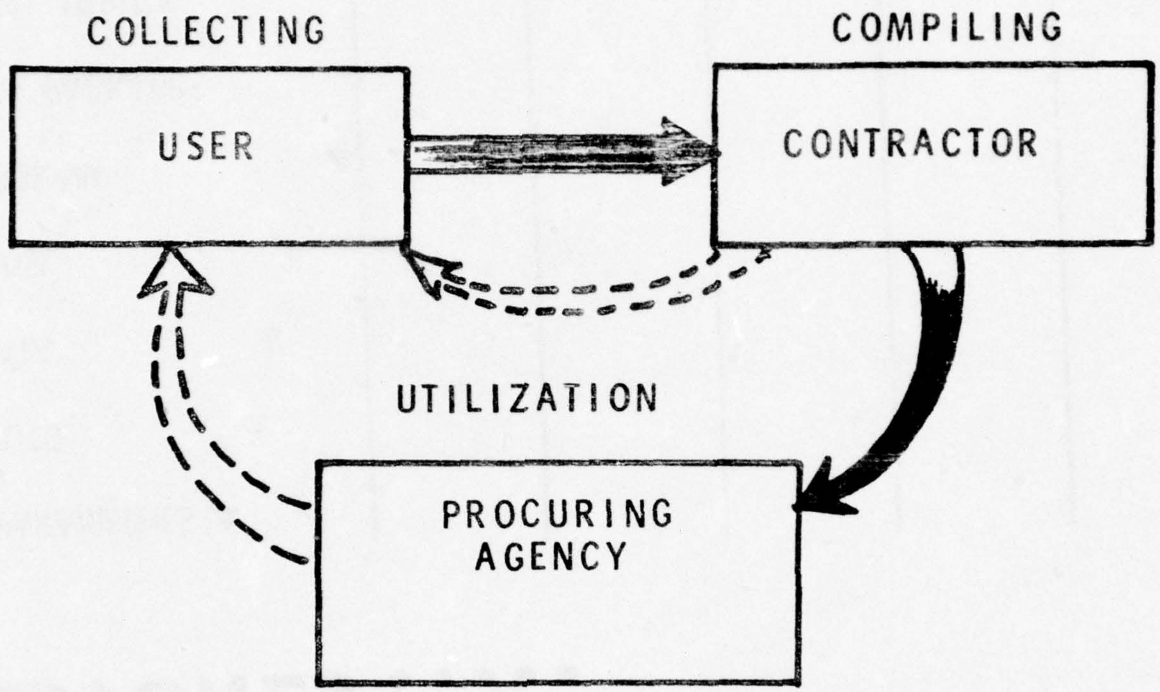
REQUIREMENT SUMMARY



PROGRAM PROGRESS TABULATION

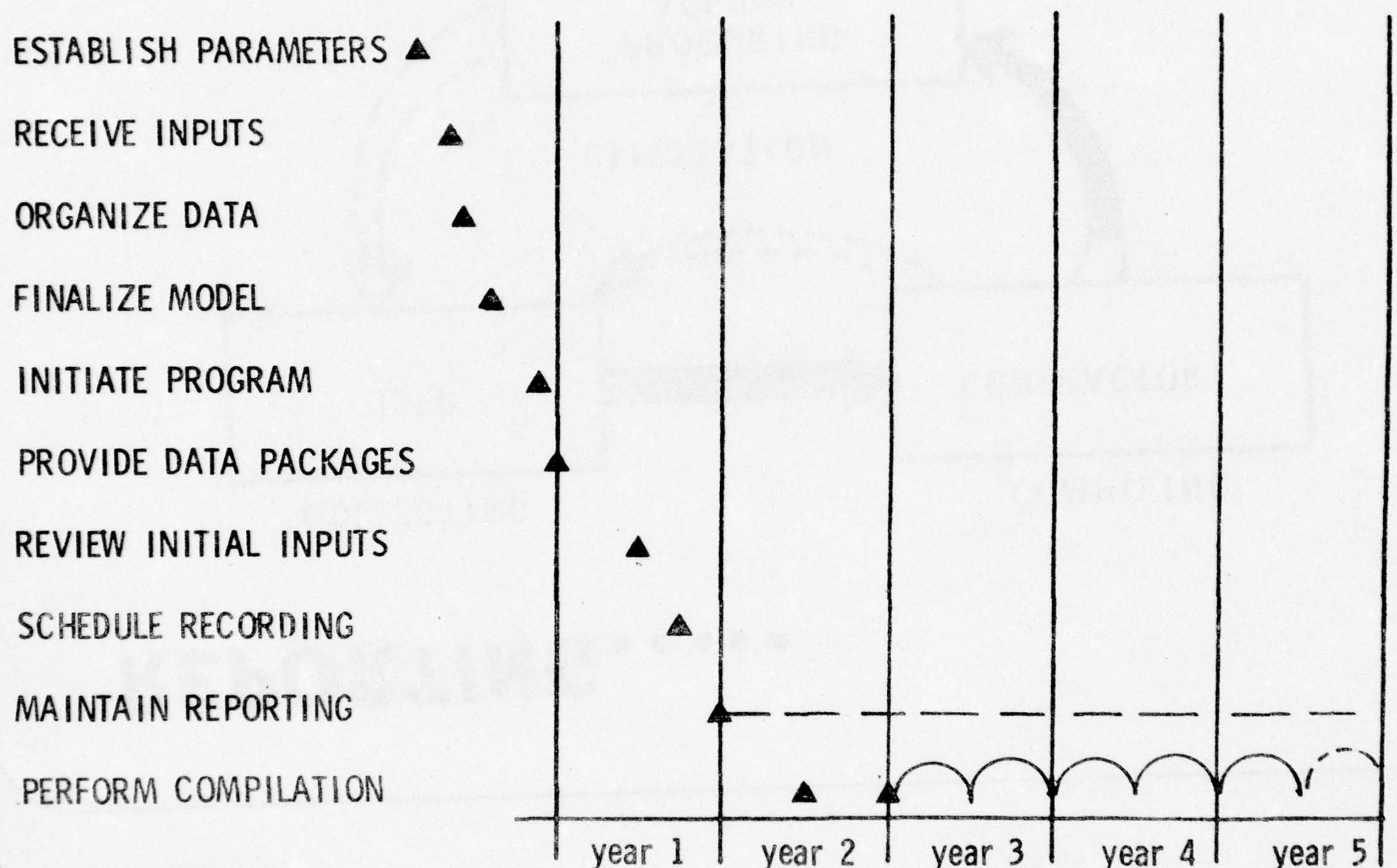
NORTHROP
ELECTRONICS DIVISION

REPORTING.....

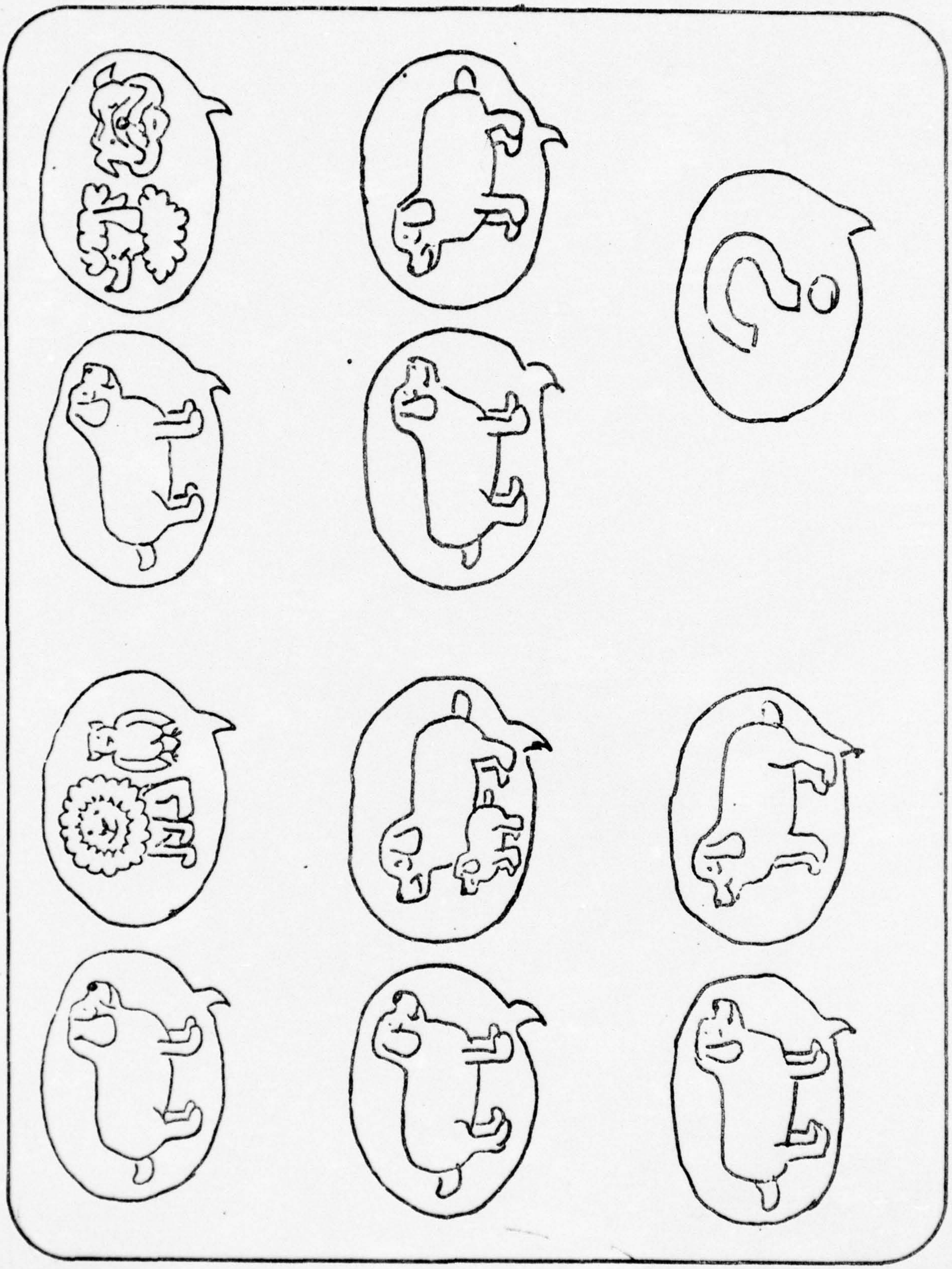


NORTHROP
ELECTRONICS DIVISION

MILESTONES .....



NORTHROP
ELECTRONICS DIVISION



4.5 ACQUISITION HARDWARE COST ESTIMATING METHODOLOGY FOR INERTIAL NAVIGATION SYSTEMS

Mrs. Freda W. Kurtz (AFAL/RWA-3)
Wright-Patterson Air Force Base
Ohio

Prior to the LCC Winter Meeting, Mrs. Kurtz had circulated a letter on this subject to various groups in the inertial systems community. At her request, time was granted at the meeting to further explain her requirements.

This section contains a copy of Mrs. Kurtz's original letter, the equations which accompanied it and an approximation of her remarks at the meeting.

AIR FORCE AVIONICS LABORATORY (AFSC)
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

3 FEB 1975

REPLY TO ATTN OF: AFAL/RWA-3 (Freda W. Kurtz/56843)

SUBJECT: Cost Estimating Methodology for Inertial Navigation Systems

TO:

1. The Air Force Avionics Laboratory is endeavoring to implement certain changes in cost estimating methodology for inertial navigation systems. Efforts have been initiated to determine a subsystem breakdown for inertial navigation systems and to develop appropriate algorithms for each subsystem within the breakdown categories.

2. A tentative list of subsystems has been developed and is shown on the attachment to this letter. It is expected that future experience will indicate appropriate changes to this list and to the algorithms. Quantitative factors and cost estimating relationships are not yet available due to the lack of an adequate historical cost data base. However, because of the urgent need to secure greater insight into inertial navigation system costs, the proposed algorithms are being considered as possibilities.

3. Inasmuch as it is known that you are concerned with inertial navigation systems and with cost estimating methodology used for the systems, the attached list is being submitted to you. You are invited to review the list and to submit your comments and/or suggestions. You are especially encouraged to submit comments concerning possible breakdowns appropriate for subsystems applicable for your navigation system - strapdown, local level, space stable, etc. Your suggestions will be given careful consideration by the laboratory. Appropriate ideas will be incorporated into the methodology adapted by the laboratory and recommended for use by the Air Force.

4. Please submit your comments by 1 March 1975. Questions may be discussed with Mrs. Freda W. Kurtz, telephone 513-255-6843 or 513-255-6849.

JAMES W. WALTERS, Lt Colonel, USAF
Chief, Reconnaissance and Weapon
Delivery Division

1 Atch
Draft of Proposed Cost Estimating Methodology for Inertial Navigation Systems by Subsystem Breakdown

DRAFT OF PROPOSED
COST ESTIMATING METHODOLOGY
FOR INERTIAL NAVIGATION SYSTEMS
BY SUBSYSTEM BREAKDOWN

COMPUTER (COM)

COM = CAP X UNITCOST X INDTE

CAP = Capacity in memory or other appropriate units

UNITCOST = Cost per unit of memory or other measurement of capacity

INDTE = Index of technology in range of 1 to 10.

CONTROL DISPLAY UNIT (CDU)

CDU = (DISPLTYP X NUMDIS) + (SWITCHTYP X NUMSWIT) X INDTE

DISPLTYP = Cost of display unit by type of display, i.e. cathode ray tube, light emitting diode, grain of wheat bulb, hot filament, liquid crystal, gas discharge, or electro-mechanical.

NUMDIS = Number of display units

SWITCHTYP = Cost of switch unit by type of switch, i.e. push button, rotary, or other.

NUMSWIT = Number of switch units

INDTE = Index of technology in range of 1 to 10

INERTIAL MEASURING UNIT (IMU)

IMU = ACCEL + GIMB + GYRO + HOUS

ACCEL = Cost of accelerometers

GIMB = Cost of gimbals (If Applicable)

GYRO = Cost of gyros

HOUS = Cost of housing and frame

ACCEL = ACCELEC + ACCINTE

ACCELEC = Cost of accelerometer electronics

ACCELEC = (POWDIS X UNITCOSTPOWDIS) X INDACCU

POWDIS = Number of milliwatts of power dissipation

UNITCOSTPOWDIS = Cost associated with unit of power dissipation

INDACCU = Index of accuracy of inertial measuring unit in range of 1 to 10.

ACCINTE = Cost of accelerometers integration and test

ACCINTE = ACCELEC X 10%

GIMB = GIMBELEC + GIMBINTE

GIMBELEC = Cost of gimbal electronics

GIMBELEC = NUMCON X INDTE

NUMCON = Number of connecting pins

GIMBINTE = Cost of gimbal integration and test

INDTE = Index of complexity in range of 1 to 10.

GYRO = GYROEL + GYROINTE

GYROEL = Cost of gyro electronics

GYROEL = NUMGYRO X INDTE

NUMGYRO = Number of gyros

INDTE = Index of complexity in range of 1 to 10

GYROINTE = Cost of gyro integration and test

GYROINTE = GYROEL X 10%

HOUS = HOUSEL + HOUSINTE

HOUSEL = Cost of housing and frame electronics

HOUSEL = (ALLELEC + GIMBELEC + GYROELEC) X 5%

HOUSINTE = Cost of housing and frame integration and test

HOUSINTE = HOUSEL X 10%

Acquisition Hardware
Cost Estimating Methodology
for Inertial Navigation Systems

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The Air Force Avionics Laboratory is currently endeavoring to improve the cost estimating methodology for inertial navigation systems. One area on which attention is being concentrated is the acquisition hardware. The goal is to provide increased visibility of the hardware cost by showing estimates by subsystem breakdown.

The defining of appropriate meaningful subsystems or components for cost estimating purposes is itself a difficult task. The most common subsystems of inertial navigation hardware are computer, display unit, and inertial measuring unit. However, the definition of even these basic elements is not consistent for all systems.

The nomenclature for the categories within these basic subsystems is even more difficult. When an attempt is made to decide on the designations for the next level of indentation in the cost estimating structure, it is difficult to bridge the differences inherent in the engineering concepts of the systems of different contractors. The need is for generic terms which will be appropriate for the inertial navigation systems of all contractors.

At the request of higher headquarters, the Air Force Avionics Laboratory has formulated a tentative subsystem breakdown and cost estimating algorithms for each subsystem. It is recognized that these are inchoative in nature. It is intended that they serve as "straw men" or "sounding boards" for the purpose of eliciting constructive comments and suggestions from the inertial navigation industrial representatives and from appropriate non-profit and government organizations.

The tentative subsystem breakdown and algorithms were sent to a list of interested representatives including most of the members of the Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Navigation Systems. The letter of transmittal was dated 3 February 1975, and requested comments by 1 March 1975. It has become possible to relax that date, and comments received by the middle of March will receive careful consideration by the Laboratory. In addition, there will be a continuing program to refine and improve the hardware cost estimating methodology. Consequently, the Laboratory is requesting information concerning suggestions which may be developed by persons during the next several months.

It is considered that this work is not in conflict with the project of developing a computer cost estimating model which has been undertaken by the Life Cycle Cost Task Group. That model, which is now almost ready for programming work, handles acquisition hardware as a single entry cost estimate. The Laboratory is, as has been pointed out, endeavoring to develop methodology that will provide visibility into the cost of the subsystems comprising the acquisition hardware.

The members of this Task Group are the persons who possess the greatest expertise in matters of inertial navigation cost estimating methodology. The Laboratory is looking to these members for help in the difficult area.

Let us consider, the example of a home builder. After he has employed an architect and has house plans drawn for a future home, he can determine the cost estimates for the house. Then if questions arise about the additional cost that would be assoicated with the cost of increasing the number of bedrooms, of adding an additional closet, or of finishing an attic area, he can secure estimates for these items and know their impact on the total cost. Likewise, if it is necessary to economize, he can get an estimate of the dollar savings associated with reducing the size of the living room, eliminating a guest bedroom, or foregoing central air-conditioning. Theoretically, the military

should be able to determine the cost associated with a requirement for an inertial navigational system of increased accuracy, with greater meantime between repair actions, or with reduced calibration time. Of course, houses have been build for centuries, and there is a long history of construction costs. Even so, as many persons have been made keenly aware, the cost estimates associated with homes are not one hundred percent accurate. The development of cost estimates for inertial navigation systems is more difficult than the prediction of house construction costs. Inertial navigation systems are a modern development. There is no long history of centuries of experience. Inertial navigation systems are the result of modern technology which is still extremely dynamic in nature.

In spite of the difficulty the economic environment in which today's weapon systems are developed and procured is such that the task of providing improved cost estimating capability cannot be ignored. The tasks can neither be disregarded nor postponed. The Laboratory has been given the responsibility. We will do the best we can. We believe we can do better with the help of the industrial companies and other organizations represented here than we could do alone. Send us your initial suggestions by the middle of March 1975. Also send us any additional comments which may arise in connection with your work during the next several months that you consider would be helpful in this project.

This paper has been prepared to summarize the comments made concerning the work being undertaken by the Air Force Avionics Laboratory to develop cost estimating methodology for inertial navigation systems acquisition hardware by subsystem. It is not an exact text of the comments.

5. MINUTES OF THE MEETING OF THE LCC TASK GROUP EXECUTIVE BOARD AT ST. PETERSBURG BEACH, FLORIDA FEBRUARY 27, 1975

MEMBERS PRESENT:

Russell B. Stauffer (DRC) - Chairman
Robert Adel (Northrop)
Keith Gibson (Autonetics)
Peter Palmer (CSDL)

MEMBERS ABSENT:

Lt. Dwight Collins (AFLC)
Don Hunt (AGMC), former Vice-Chairman who has resigned as a result of a change in work assignment.

1. Based on the authority granted to the Executive Board in the revised LCC Task Group Charter adopted at the quarterly meeting in November 1974 at Redondo Beach, California - William Laird (NARF, North Island) was elected to the Executive Board and Peter Palmer (CSDL) was elected Vice-Chairman.

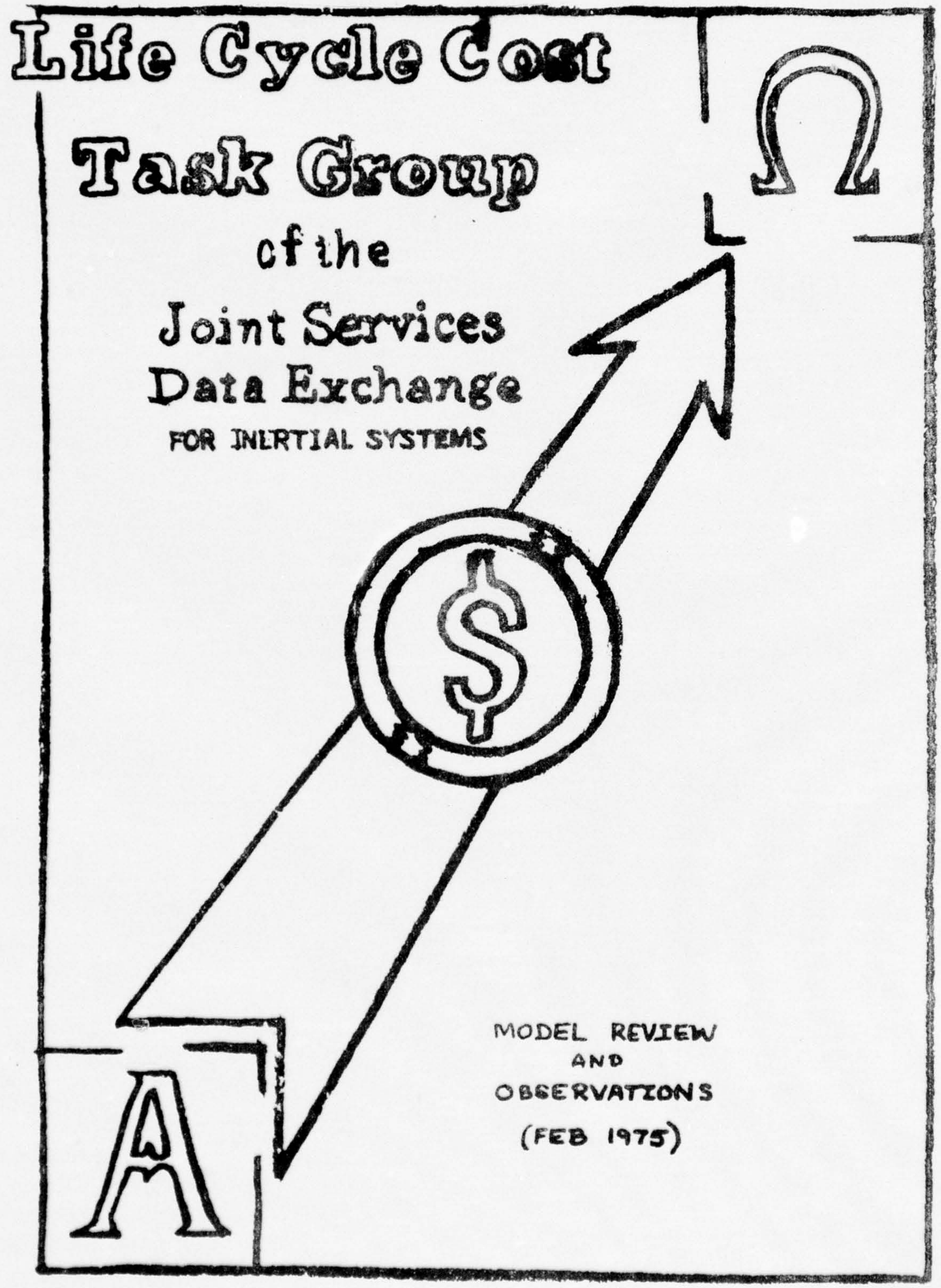
2. The next meeting of the LCC Task Group will be held in Dayton, Ohio on 29-31 July, 1975. Each member of the Executive Board will try to obtain a commitment from a speaker for that meeting within the next six weeks and forward the speaker's name, address, telephone number, title of the talk, and subject matter to the chairman.

3. Keith Gibson will assign the tasks to the working parties at the July meeting. Also, a working party will be formed to establish the numerical values for those constants which must be sized by the governmental agencies.

4. Russell Stauffer will propose to the chairman of the Planning Group of the JSDE/IS that the LCC Task Group will make two presentations at the November, 1975 meeting of the JSDE/IS. One presentation will be by Robert Adel on the objectives, accomplishments, and future plans of the LCC Task Group. The vugraphs for this presentation were shown to the LCC Task Group at the St. Petersburg, Florida meeting and were based on material drafted by Robert Adel, Lt. Dwight Collins, Terry Rucker (Navy) and Russell Stauffer at the November 1974 meeting. The other presentation will be made by Keith Gibson to bring the parent group up-to-date on the LCC modeling efforts.

APPENDIX A

MODEL REVIEW AND OBSERVATIONS


Life Cycle Cost
Task Group
of the
Joint Services
Data Exchange
FOR INLRTIAL SYSTEMS
MODEL REVIEW
AND
OBSERVATIONS
(FEB 1975)

LCCTG HANDOUT

ERRATA SHEET

PAGE	TYPED LINE	CHANGE
I-2	5	PROPT to PROP7
II-1	33	DPM to HPM
II-2	5	QPSI to QPS_i
II-12	20	Days/Month DPM Days to Hours/Month HPM* Hours
	21	WCDR to WCDR*
	22	AASR to AASR*
	23	UF to UF*
II-15		Add footnote: * Not called out in model
III-4		Add: $MCPR_{ki} \left\{ \begin{matrix} MCPRD_i \\ MCPRI_i \end{matrix} \right\}$
III-6	14	REMK to REMK*
		Add footnote
		*Not called out in model
IV-3		Under heading TSEA add:
		"$SESO_k$ in text (2 places) replaced with $SEMO_k$ in equation for $SEAPAR_k$".

TABLE OF CONTENTS

RDT&E

ELEMENT	COMPUTED	INPUT	OUTPUT
R	X		
CS	X		
TI1		X	
EH		X	
SAH		X	
CST		X	
DE	X		
PROP1		X	
ACC		X	
PROP2		X	
MTBF		X	
PROP3		X	
MTTR		X	
PROP4		X	
AT		X	
E		X	
DEP		X	
TSR	X		
TSH	X		
DPC		X	
NTH		X	
TSS	X		
DPC		@	
LTP		X	
TVOP		X	
MTBF		@	
SF		X	
TSER	X		
DPCZ		X	
NTH		@	
LTP		@	
TVOP		@	
COH		X	
*TSR	X		
TSRP		X	
PC		X	
PCP		X	
TDR	X		
CTD		X	
TDP		X	
CD		X	
TDD		X	

* ALTERNATE EQUATION
@ PREVIOUSLY LISTED

RDT&E

ELEMENT	COMPUTED	INPUT	OUTPUT
SWR	X		
SWRP		X	
PC		⊠	
PCP		⊠	
PROPT		X	
TNR	X		
TNER	X		
NTI		X	
DPC		⊠	
NTL		X	
DPCA		X	
TNP	X		
TVOC		X	
TVOPT		X	
MCM		X	
LTP		⊠	
MHG		X	
GTNH		X	
TNCH		X	
ECP	X		
NECP		X	
NV		X	
PROP5		X	
QPV		X	
PC		⊠	
VEC		X	
PROP6		X	
PCZ		X	
*ECP	X		
NECP		⊠	
PC		⊠	
K		X	
RPM	X		
RPMC		X	
RPMG	X		
TI2		X	
RPMGP		X	

* ALTERNATE EQUATION
⊠ PREVIOUSLY LISTED

100 Common Data

Identifies data elements common to multiple equations.

101 Conceptual Studies

Identifies costs associated with conceptual studies on a previous system of similar design and includes a technology index to compensate for improvements in methods and techniques.

102 Design Engineering

Identifies parameters impacting design engineering costs (Accuracy, MTBF, MTTR, Alignment Time), proportionality factors to relate current requirements to a previous system of similar design, an environmental stress factor, and the design engineering costs of the previous system.

103 Testing

Identifies parameters impacting testing costs applicable to the areas of spares, hardware and support equipment.

104 Testing (Alternate)

Identifies parameters to relate current testing costs to the testing costs of a previous program of similar design.

105 Technical Data

Identifies parameters impacting the costs of technical data during RDT&E.

106 Software

Identifies parameters to relate current software costs to the software costs of a previous system of similar design.

107 Training

Identifies the parameters impacting training costs applicable to the areas of training hardware, support equipment, and personnel.

108 Engineering Change Proposals

Identifies parameters to relate current ECP Costs to ECP Costs for a previous system of similar design. Data includes support equipment considerations.

109 Engineering Change Proposals (Alternate)

Identifies parameters for computing ECP costs as a percentage of production costs.

110 Program Management

Identifies parameters for computing total program management costs shared by the contractor and the government. Government costs are computed as a function of the costs for management of a previous system of similar design and a technology index to compensate for improvements in methods and techniques.

COMPUTES	CC	DATA	SYMBOL	UNITS	VALUE RANGES
Common Data	1- 3	Card Number	-	-	100
	4- 8	Mean Time Between Failures	MTBF	Hours	00000-99999
	9-16	Development Production Costs	DPC	$	000000.00-999999.99
	17-24	Production Cost/Unit of Prime Hardware	PC	$	000000.00-999999.99
	25-32	Production Cost/Unit of Prime Hardware (Previous)	PCP	$	000000.00-999999.99
	33-34	Length of Test Program	LTP	Months	00-99
	35-36	Number of ECP's	NECP	#	000-999
CS	1- 3	Card Number	-	-	101
	7-10	Technology Index	TI_1	T	0000-9999
	11-20	Engineering Hours Cost	EH	$	00000000.00-99999999.99
	21-30	System Analysis Hours Cost	SAH	$	00000000.00-99999999.99
	31-40	Computer Simulation Time Cost	CST	$	00000000.00-99999999.99
DE	1- 3	Card Number	-	-	102
	5-10	Required System Accuracy	ACC	?	000000-999999
	11-15	Proportionality Factors	PROP1	-	00000-99999
	16-20		PROP2	-	00000-99999
	23-25	Mean Time To Repair	MTTR	Hours	00.0-99.9
	26-30	Proportionality Factor	PROP3	-	00000-99999
	33-35	Alignment Time	AT	Hours	00.0-99.9
	36-40	Proportionality Factor	PROP4	-	00000-99999
	41-45	Environmental Stress Factor	E	-	00000-99999
	46-55	Design Engineering Costs (Previous)	DEP	$	00000000.00-99999999.99
TSR	1- 3	Card Number	-	-	103
	4- 5	Number of Units of Test Hardware	NTH	#	00-99
	6- 8	Test Vehicle Operating Hours/Month	TVOP	HRS/MTH	000-774
	9-13	Safety Factor	SF	-	00000-99999
	14-22	Development Production Cost of Special Engineering Test Equipment	DPCZ	$	0000000.00-9999999.99
	23-29	Cost/Test Operating Hour	COH	$	00000.00-99999.99
TSR (ALT)	1- 3	Card Number	-	-	104
	4-13	Cost of Test Program (Previous)	TSRP	$	00000000.00-99999999.99

COMPUTES	CC	DATA	SYMBOL	UNITS	VALUE RANGES
TDR	1- 3	Card Number	-	-	105
	6-10	Average Cost/Page of Tech. Data	CTD	$	000.00-999.99
	12-15	Number of Pages of Tech. Data	TDP	Pages	0000-9999
	17-21	Average Cost/Page of Drawings	CD	$	000.00-999.99
	27-30	Number of Pages of Drawings	TDD	Pages	0000-9999
SWR	1- 3	Card Number	-	-	106
	4-11	Cost of Software (Previous)	SWRP	$	000000.00-999999.99
	16-20	Proportionality Factor	PROP7	-	00000-99999
TNR	1- 3	Card Number	-	-	107
	4- 5	Number of Training Units	NTI	#	00-99
	6- 8	Number of Training Locations	NTL	#	00-99
	9-15	Development Production Cost of AGE	DPCA	$	00000.00-99999.99
	16-22	Test Vehicle Hourly Operating Cost	TVOC	$	00000.00-99999.99
	23-25	Test Vehicle Operating Hours for Training	TVOPT	Hours	000-999
	26-31	Personnel Cost/Training Hour	MHG	$	0000.00-9999.99
	32-34	Ground Training Hours with Prime Eqpt.	GTNH	Hours	000-999
	35-37	Test Equipment Training Hours	TNCH	Hours	000-999
	38-44	Manpower Cost/Month	MCM	$	00000.00-99999.99
ECP	1- 3	Card Number	-	-	108
	4	Quantity/Vehicle	QPV	#	0-9
	5- 7	Number of Vehicles	NV	#	000-999
	8-12	Proportionality Factor	PROP5	-	00000-99999
	13-20	Production Cost of AGE	PCZ	$	000000.00-999999.99
	31-35	Proportionality Factor	PROP6	-	00000-99999
	36-42	Cost to alter each Vehicle	VEC	$	00000.00-99999.99
ECP (ALT)	1- 3	Card Number	-	-	109
	5- 7	Cost of ECP's Expressed as a Percentage of Production Costs	K	%	000-100
RPM	1- 3	Card Number	-	-	110
	7-15	Contractor Program Management Cost	RPMC	$	0000000.00-9999999.99
	22-30	Government Program Mgmt. Cost (Previous)	RPMGP	$	0000000.00-9999999.99
	32-35	Technology Index	TI2	-	0000-9999

ACQUISITION

ELEMENT	COMPUTED	INPUT	OUTPUT
A	X		
TTEA	X		
CTE_j		X	
QTE_j		X	
SRAC	X		
NS		X	
UC_q		X	
CINST	X		
NI		X	
CI		X	
CSU	X		
$CSUA_j$		X	
TSEA	X		
$SEAMOD_k$	X		
$TSEA_k$	X		
$SESM_k$		X	
$SEAPAR_k$	X		
$TSEA_k$	X		
$SEMO_k$		X	
$TSEA_k$	X		
NSE_k	X		
RSE_{kj}	X		
SOH		X	
$MTBMA_i$	X		
K1		X	
$MTBF_i$		X	
QPS_i		X	
$NOPS_k$		X	
$SETT_{ijk}$		X	
CF_i		X	
$SECT_{ijk}$		X	
ASE	X		
DPM		X	
WCDR		X	
AASR		X	
UF		X	
CSE_{kj}		X	
NRS_k		X	
TDA	X		
NTOD		X	
CP		X	
TDV		X	
TDG		X	
TDIC		X	
TNEA	X		
$TNEA_k$		X	
NRS_k		@	

@ PREVIOUSLY LISTED

ACQUISITION

ELEMENT	COMPUTED	INPUT	OUTPUT
SPHA	X		
λ_i	X		
SOH		Ø	
NOS		X	
QPSI		Ø	
$MTBMA_i$	X		
K_i		Ø	
$MTBF_i$		Ø	
t_i	X		
$NRTS_i$		X	
DTAT		X	
RTS_i		X	
ITAT		X	
SLRU	X		
N_i	X		
C_i		X	
IL		X	
SSRU	X		
N_i	X		
C_i		X	
IL		Ø	
SCOND	X		
$NCOND_i$	X		
$TCOND_i$	X		
SOH		Ø	
TNOS		X	
PIUP		X	
$MTBMA_i$	X		
K1		Ø	
$MTBF_i$		Ø	
$NNCOND_i$	X		
$CCOND_i$	X		
SPARTS	X		
K2		X	
SRAC	X		
TNA	X		
TNA_k	X		
NC_k		X	
ICL_k		X	
LRI_k		X	
NI_k		X	
LRS_k		X	
NS_k		X	
CP_k		X	
CM_k		X	

Ø PREVIOUSLY LISTED

ACQUISITION

ELEMENT	COMPUTED	INPUT	OUTPUT
FEC	X		
NFE		X	
CFER		X	
NRS		X	
FACA	X		
$CFACA_j$		X	
$QFACA_j$		X	
IIMA	X		
IMCA		X	
NPTA		X	
NATA		X	

⊠ PREVIOUSLY LISTED

200 Common Data

Identifies parameters required by multiple sub-equations.

201 Tooling and Test Equipment *Nomenclature*

Identifies five separate items of tooling and/or test equipment required to initiate production. Each card contains a suffix number (00-99) which serves to relate a specific 201 card to its associated 202 card and also to index individual items on each card. The indexing scheme is: j=5 x Suffix + 1,(e.g. Item 3 will be the 3^{rd} item on card 201 suffix 00, item 22 will be the 2^{nd} item on card 201 suffix 04, item 93 will be the 3^{rd} item on card 201 suffix 18).

202 Tooling and Test Equipment *Cost & Quantity*

Identifies the costs and quantities of 5 items of tooling and/or test equipment required to begin production. Each card contains a suffix which serves to relate it to a card 201 counterpart and to index the specific items. The indexing scheme is identical to card 201.

203 System Acquisition Costs

Identifies parameters to compute hardware acquisition costs. A data field is included to compute spare O&M parts since the model identifies this cost as a function of SPAC.

204 installation Costs

Identifies parameters to compute system installation costs.

205 Program Start-Up Costs

Identifies five separate start-up items and their costs. Each card contains a suffix (00-99) which is used to index the individual items. The indexing scheme is: j=4 x Suffix + 1 (e.g., Item 4 will be the 4^{th} item on card 205 suffix 00, item 17 will be the 1^{st} item on card 205 suffix 04, the 32^{nd} item will be the 4^{th} item on card 205 suffix 07.

206 Support Equipment Data

Identifies a specific item of support equipment, (SE) assigns it a card suffix to be used as an internal identification number and lists the following parameters:

a. Cost of the item (CSE)
b. Average hours per maintenance action that this item will be used from fault isolation through acceptance testing of the i^{th} LRU/SRU at each of the 3 levels of maintenance.
c. Average hours that this item will be used per calibration of the i^{th} LRU/SRU at each of the 3 levels of maintenance.

In the event that a single item of SE is applicable to a number of LRU/SRU's and the maintenance and calibration times differ for the different LRU/SRU applications, separate cards with different suffixes will assign the correct times to the individual LRU/SRU's. (e.g., Assume that a Test Set 977G-2 which costs $6500, is required to troubleshoot and calibrate LRU/SRU 819G-3A1 and 819G-3A3 with the following time requirements:

	SETT (HRS.)			SECT (HRS.)		
LRU/SRU	O	I	D	O	I	D
819G-3A1	0.0	3.5	6.7	0.0	3.0	3.0
819G-3A3	0.0	4.3	7.7	0.0	2.5	2.5

The formats of the cards 206 might become:

CC	DATA	DATA
1 - 3	206	206
4 - 5	01	02
6 -20	TEST SET 977G-2	TEST SET 977G-2
21-29	bbb650000	bbb650000
30-33	bb00	bb00
34-37	bb35	43
38-41	bb67	77
42-45	bb00	00
46-49	bb30	25
50-53	bb30	25

Then, card 207 suffixed to identify LRU/SRU 819G-3 A1 will contain 01 as an entry for both I Level and Depot Level SE requirements, and card 207 suffixed to identify LRU/SRU 819G-3 A3 will contain 02 as an entry for both I Level and Depot Level SE requirements.

207 LRU/SRU DATA

Identifies specific LRU/SRU in system and assigns a card suffix number which will become an internal Identification number. The card contains the following data concerning the LRU/SRU.

a. Mean Time Between Failures (MTBF)
b. Return to depot rate (NRTS)
c. Repair at base rate (RTS)
d. Quantity of this item per system (QPS)
e. Cost of this item (C)
f. Calibration frequency (CF)
g. O Level support equipment (SE) required (3 items) identified by the SE card (206) suffix number assigned to a specific item of SE.
h. I Level SE required (7 items) identified by the SE card (206) suffix number assigned to a specific item of SE.
i. D Level SE required (8 items) identified by the SE card (206) suffix number assigned to a specific item of SE.

e.g., Assume SRU A1 of LRU 819G-3 has the following parameters defined on card 207-04.

a. MTBF - 5000 hours
b. NRTS - 30 percent
c. RTS - 70 percent
d. QPS 3
e. C $2600
f. CF -
g. O Level Support Equipment
   1. Defined on card 206-01
   2. Defined on card 206-15
h. I Level Support Equipment
   1. Defined on card 206-12
   2. Defined on card 206-13
   3. Defined on card 206-14
   4. Defined on card 206-15
i. Depot Level Support Equipment
   1. Defined on card 206-13
   2. Defined on card 206-14
   3. Defined on card 206-15
   4. Defined on card 206-16
   5. Defined on card 206-17

The input data card would be formatted as (b=blanks):

CC	DATA
1 - 3	207
4 - 6	04
7 -11	819G3
12-20	bbbbbbbA1
21-25	b5000
26-28	b30
29-31	b70

CC	DATA
32-33	b3
34-41	bb260000
42-44	005
45-46	01
47-48	15
49-50	bb
51-52	12
53-54	13
55-56	14
57-58	15
59-60	bb
61-62	bb
63-64	bb
65-66	13
67-68	14
69-70	15
71-72	16
73-74	17
75-76	bb
77-78	bb
79-80	bb

208 Support Equipment Costs

Identifies parameters to be used with other internal computations to determine the support equipment costs at each maintenance level.

209 Technical Data Costs

Identifies the parameters impacting the costs of producing and introducing into government inventory the requisite technical data for the system.

210 Training Equipment Costs

Lists the training equipment acquisition costs at each maintenance level.

211 Spares Costs

Identifies parameters, used in conjunction with internally computed parameters, to determine sparing costs for up to 15 inventory location types. Each card contains a suffix (0-9) which is used to expand the total capability to 135 separate inventory location types.

212 Training Costs

Identifies parameters impacting training costs at a specific maintenance level. Each card contains a suffix (1-3) which identifies the maintenance level of interest.

213 Field Engineering Costs

Identifies the parameters impacting field engineering costs.

214 Facilities

Identifies 6 separate new facilities required for the program. Each card contains a suffix (000-999) which is used to relate a specific 214 card to its associated 215 card and to index individual items on each card. The indexing scheme is: j=6 x Suffix + 1,(e.g. Item 5 is the 5th item on card 214 suffix 000, item 29 is the 5th item on card 214 suffix 004 and item 127 is the 1st item on card 214. suffix 21).

215 Facilities

Identifies the costs and quantities of 6 new facilities required for the program. Each card contains a suffix which serves to relate it to a card 214 counterpart and to index the specific facility. The indexing scheme is identical to card 214.

216 Item Introduction Costs

Identifies the parameters necessary to compute the costs of introducing new parts/assemblies into the government inventory.

COMPUTES	CC	DATA	SYMBOL	UNITS	VALUES
Common Data	1- 3	Card Number	-	-	200
	4- 6	Total Number of Operating Systems	TNOS	#	001-999
	7- 9	Avg. Op. Hrs./System/Month	SOH	Hours	001-744
	10-12	Projected Inventory Usage Period	PIUP	Months	001-999
	13-15	Ratio of Calculated Failures to Anticipated Maintenance Actions	K1		0.00-9.99
	16-17	Depot Turn-Around-Time	DTAT	Months	00-99
	18-19	I Level Turn-Around-Time	ITAT	Months	00-99
	20-22	Number of O Level Repair Shops	NRS_1	#	000-999
	23-25	Number of I Level Repair Shops	NRS_2	#	000-999
	26-28	Number of Depots	NRS_3	#	000-999
TTEA	1- 3	Card Number	-	-	201
	4- 5	Card Suffix	-	#	00-99
	6-20	Tooling.Test Equipment j Nomenclature	$TENOM_j$*	-	(j=5xSUFFIX+1)
	21-35	j + 1	-	-	-
	36-50	j + 2	-	-	-
	51-65	j + 3	-	-	-
	66-80	j + 4	-	-	-
TTEA	1- 3	Card Number	-	-	202
	4- 5	Card Suffix	-	#	00-99
	6-13	CTE_j (j = 5xSUFFIX+1)	CTE_j	$	000000.00-999999.99
	14-16	QTE_j	QTE_j	#	000-999
	17-24	CTE_{j+1}			
	25-27	QTE_{j+1}			
	28-35	CTE_{j+2}			
	36-38	QTE_{j+2}			
	39-46	CTE_{j+3}			
	47-49	QTE_{j+3}			
	50-57	CTE_{j+4}			
	58-60	QTE_{j+4}			

* Not called out in the model

COMPUTES	CC	DATA	SYMBOL	UNITS	VALUE
SRAC	1- 3	Card Number	-	-	203
SPARTS	6- 8	Quantity of Systems Purchased	NS	#	001-999
	9-17	Average Unit Cost	UC_q	$	0000000.00-9999999.9
	18-21	Spare O&M Parts Expressed as a Percentage of SRAC	K2	%	000.0-100.0
CINST	1- 3	Card Number	-	-	204
	6- 8	Number of Installations	NI	#	001-999
	9-17	Average Cost/Installation	CI	$	0000000.00-9999999.9
CSU	1- 3	Card Number	-	-	205
	4- 5	Card Suffix	-	#	00-99
	6-14	Program Start-Up Item j Nomenclature	$SUNOM_j$*	-	(j=4xSUFFIX+1)
	15-23	Cost of Start-Up Item j	$CSUA_j$	$	0000000.00-9999999.9
	24-32	$SUNOM_j + 1$		-	
	33-41	$CSUA_j + 1$		$	
	42-50	$SUNOM_j + 2$		-	
	51-59	$CSUA_j + 2$		$	
	60-68	$SUNOM_j + 3$		-	
	69-77	$CSUA_j + 3$		$	
SUPPORT	1- 3	Card Number	-	-	206
EQPT.	4- 5	Card Suffix	-	-	00-99
DATA	6-20	Support Equipment Nomenclature	$SENOM_j$*	-	(j=4SUFFIX+1)
	21-29	Cost of SE_j	CSE_j	$	0000000.00-9999999.9
	30-33	SE_j Troubleshoot Time O Level	$SETT_{ij1}$	Hours	000.0-999.9
	34-37	i Level	$SETT_{ij2}$	Hours	000.0-999.9
	38-41	Depot	$SETT_{ij3}$	Hours	000.0-999.9
	42-45	SE_j Calibration Time O Level	$SECT_{ij1}$	Hours	000.0-999.9
	46-49	I Level	$SECT_{ij2}$	Hours	000.0-999.9
	50-53	Depot	$SECT_{ij3}$	Hours	000.0-999.9

* Not called out in the model

COMPUTES	CC	DATA	SYMBOL	UNITS	VALUE
LRU/SRU DATA	1- 3	Card Number	-	-	207
	4- 6	Card Suffix	-	-	000-999
	7-11	LRU Identity	LRUID*	-	Nomenclature
	12-20	SRU Identity	SRUID*	-	Nomenclature
	21-25	Item Mean Time Between Failure	$MTBF_i$	Hours	00000-99999
	26-28	Percent Failures Returned to Depot	$NRTS_i$	%	000-100
	29-31	Percent Failures Returned to Base	RTS_i	%	000-100
	32-33	Quantity This Item/System	QPS_i	#	01-99
	34-41	Cost of This Item	C_i	$	000000.00-999999.99
	42-44	Calibration Frequency	CF_i	#/OP. HR.	.000-.999
	45-46	O Level SE (Parallels Card 206 Suffix)	OSE1*	#	00-99
	47-48		OSE2*		00-99
	49-50		OSE3*		00-99
	51-52	I level SE (Parallels Card 206 Suffix)	ISE1*		00-99
	53-54		ISE2*		00-99
	55-56		ISE3*		00-99
	57-58		ISE4*		00-99
	59-60		ISE5*		00-99
	61-62		ISE6*		00-99
	63-64				00-99
	65-66	Depot Level SE (Parallels Card 206 Suffix)	DSE1*		00-99
	67-78		DSE2*		00-99
	69-70		DSE3*		00-99
	71-72		DSE4*		00-99
	73-74		DSE5*		00-99
	75-76		DSE6*		00-99
	77-78		DSE7*		00-99
	79-80		DSE8*		00-99

* Not called out in the model.

COMPUTES	CC	DATA	SYMBOL	UNITS	VALUES
TSEA	1- 3	Card Number	-	-	208
	4- 6	Cost of Spare Modules Expressed as a Percentage of SE Acquisition Cost for O Level.	$SESM_1$	%	000-100
	7- 9	Cost of Spare Modules Expressed as a Percentage of SE Acquisition Cost for I Level	$SESM_2$	%	000-100
	10-12	Cost of Spare Modules Expressed as a Percentage of SE Acquisition Cost for Depot	$SESM_3$	%	000-100
	13-15	Cost of O&M Spare Parts for SE Expressed as a Percentage of SE Acquisition Cost for O Level	$SEMO_1$	%	000-100
	16-18	Cost of O&M Spare Parts for SE Expressed as a Percentage of SE Acquisition Cost for I Level	$SEMO_2$	%	000-100
	19-21	Cost of O&M Spare Parts for SE Expressed as a Percentage of SE Acquisition Cost for Depot	$SEMO_3$	%	000-100
	22-24	Number of Operating Systems Maintained at the O Level	$NOPS_1$	#	000-100
	25-27	Number of Operating Systems Maintained at the I Level	$NOPS_2$	#	000-999
	28-30	Number of Operating Systems Maintained at the Depot	$NOPS_3$	#	000-999
	31-32	Days/Month	DPM	DAYS	00-31
	33-35	Working Day to Calendar Day Ratio	WCDR	#	0.00-1.00
	36-38	Assigned Shifts to Available Shifts Ratio	AASR	#	0.00-1.00
	39-41	Utilization Factor	UF	%	000-100

COMPUTES	CC	DATA	SYMBOL	UNITS	VALUE
TDA	1- 3	Card Number	-	-	209
	4- 6	Non-T.O. Data Cost Expressed as a Percentage of T.O. Data Costs	NTOD	%	000-100
	7-11	Cost/Page of T.O. Data	CP	$	000.00-999.99
	12-15	Number of Pages Prime Hardware T.O.'s	TDV	#	0000-9999
	16-19	Number of Pages AGE T.O.'s	TDG	#	0000.9999
	20-22	One-Time Introduction Cost/Page	TDIC	$	0.00-9.99
TNEA	1- 3	Card Number	-	-	210
	4-12	Training Equipment Acquisition Cost, O Level	$TNEA_1$	$	0000000.00-9999999.9
	13-21	Training Equipment Acquisition Cost, I Level	$TNEA_2$	$	0000000.00-9999999.9
	22-30	Training Equipment Acquisition Cost, Depot	$TNEA_3$	$	0000000.00-9999999.9
SPHA	1- 3	Card Number	-	-	211
	4	Card Suffix	-	-	0-9
	5- 7	Number of Operating Systems Serviced by Location j	NOS_j	#	000-999
	8- 9	Number of Inventory Locations Identical to Location j	IL_j	#	01-99
	10-12		NOS_{j+1}		
	13-14		IL_{j+1}		
	15-17		NOS_{j+2}		
	18-19		IL_{j+2}		
	20-22		NOS_{j+3}		
	23-24		IL_{j+3}		
	25-27		NOS_{j+4}		
	28-29		IL_{j+4}		
	30-32		NOS_{j+5}		
	33-34		IL_{j+5}		
	35-37		NOS_{j+6}		
	38-39		IL_{j+6}		
	40-42		NOS_{j+7}		
	43-44		IL_{j+7}		
	45-47		NOS_{j+8}		
	48-49		IL_{j+8}		
	50-52		NOS_{j+9}		
	53-54		IL_{j+9}		
	55-57		NOS_{j+10}		
	58-59	May be expanded to cover $\left.\begin{matrix} NOS_{j+14} \\ IL_{j+14} \end{matrix}\right\}$ per card	IL_{j+10}		

COMPUTES	CC	DATA	SYMBOL	UNITS	VALUE
TNA (O Level)	1- 3	Card Number	-	-	212
	4	Card Suffix	-	-	1
	5- 7	Initial Course Length	ICL_1	Hours	000-999
	8-11	Instructor Hourly Labor Rate	LRI_1	$	00.00-99.99
	12-13	Number of Instructors	NI_1	#	00-99
	14-15	Number of Students/Class	NS_1	#	00-99
	16-19	Students Hourly Labor Rate	LRS_1	$	00.00-99.99
	20-21	Number of Courses	NC_1	#	00-99
	22-29	Course Preparation Cost	CP_1	$	000000.00-999999.99
	30-37	Course Material Cost	CM_1	$	000000.00-999999 99
TNA (I Level)	1- 3	Card Number	-	-	212
	4	Card Suffix	-	-	2
	5- 7	Initial Course Length	ICL_2	Hours	000-999
	8-11	Instructor Hourly, Labor Rate	LRI_2	$	00.00-99.99
	12-13	Number of Instructors	NI_2	#	00.99
	14-15	Number of Students/Class	NS_2	#	00.99
	16-19	Student Hourly Labor Rate	LRS_2	$	00.00-99.99
	20-21	Number of Courses	NC_2	#	00-99
	22-29	Course Preparation Cost	CP_2	$	000000.00-999999.99
	30-37	Course Material Cost	CM_2	$	000000.00-999999.99
TNA (Depot)	1- 3	Card Number	-	-	212
	4	Card Suffix	-	-	3
	5- 7	Initial Course Length	ICL_3	Hours	000-999
	8-11	Instructor Hourly Labor Rate	LRI_3	$	00.00-99.99
	12-13	Number of Instructors	NI_3	#	00-99
	14-15	Number of Students/Class	NS_3	#	00-99
	16-19	Student Hourly Labor Rate	LRS_3	$	00.00-99.99
	20-21	Number of Courses	NC_3	#	00.99
	22-29	Course Preparation Cost	CP_3	$	000000.00-999999.99
	30-37	Course Material Cost	CM_3	$	000000.00-999999.99

COMPUTES	CC	DATA	SYMBOL	UNITS	VALUE
FEC	1- 3	Card Number	-	-	213
	4- 6	Man-Months FE Services/Base	NFE	Man-Months	000-999
	7-12	Cost/Man-Month FE Services	CFER	$	0000.00-9999.99
	13-15	Number of Bases Requiring FE Services	NRS	#	000-999
FACA	1- 3	Card Number	-	-	214
	4- 6	Card Suffix	-	-	000-999
	7-16	New Facility j Identity	$FACID_j$*	-	(j = 6xSuffix +1)
	17-26		$FACID_{j+1}$*		
	27-36		$FACID_{j+2}$*		
	37-46		$FACID_{j+3}$*		
	47-56		$FACID_{j+4}$*		
	57-66		$FACID_{j+5}$*		
FACA	1- 3	Card Number	-	-	215
	4- 6	Card Suffix	-	-	000-999
	7-15	Cost of New Facility j (j= 6xSuffix+1)	$CFACA_j$	$	0000000.00-9999999.99
	16-17	Quantity of New Facility j	$QFACA_j$	#	00-99
	18-26		$CFACA_{j+1}$	$	
	27-28		$QFACA_{j+1}$	#	
	29-37		$CFACA_{j+2}$	$	
	38-39		$QFACA_{j+2}$	#	
	40-48		$CFACA_{j+3}$	$	
	49-50		$QFACA_{j+3}$	#	
	51-59		$CFACA_{j+4}$	$	
	60-61		$QFACA_{j+4}$	#	
	62-70		$CFACA_{j+5}$	$	
	71-72		$QFACA_{j+5}$	#	
IIMA	1- 3	Card Number	-	-	216
	4- 8	Initial Item Introduction Cost	IMCA	$	000.00-999.99
	9-12	Number of New Parts	NPTA	#	0000-9999
	13-16	Number of New Assemblies	NATA	#	0000-9999

O&M

ELEMENT	COMPUTED	INPUT	OUTPUT
OM	X		
OMk	X		
NRSk		X	
*WCti	X		
*TFt		X	
*Wti		X	
DLkti	X		
TFt (k=3)		@	
*RTKRkti	X		
NVt		X	
QPV		X	
QPSi		X	
SOHt		X	
*NRTSki (k=2, 1)		X	
MTBRi		X	
RIFti		X	
*RTOKki (k=3, 2)		X	
*PLVk (k=3,2)		X	
*MTTRki		X	
*DLRk		X	
*RPIFt		X	
*DMkti (k= 3, 2)	X		
TFt (k=3)		@	
RTKRkti		**	
MCPRki (k= 3,2)		X	
*OLkti	X		
TFt (k=3)		@	
DLkti		**	
*OLRk		X	
*GAti	X		
TFt (k=3)		@	
DLkti		**	
DMkti (k=3)		**	
OLkti		**	
*GARk		X	
*Tkti (k=3,2)	X		
TFt (k=3)		@	
RTKRkti		**	
POI		X	
SCO		X	
SCC		X	
Wi		X	
NRTSki (k=2)		@	

* SEE DATA ELEMENT CHANGE LISTING
** PREVIOUSLY COMPUTED DATA USED AS INPUT
@ PREVIOUSLY LISTED

O&M

ELEMENT	COMPUTED	INPUT	OUTPUT
RDtki (k=3,2)	X		
TFt (k=3)		@	
RTKRkti		**	
*CONDki (k=3,2)		X	
PCti		X	

* SEE DATA ELEMENT CHANGE LISTING
**PREVIOUSLY COMPUTED DATA USED AS INPUT
@ PREVIOUSLY LISTED

DATA ELEMENT CHANGE LISTING

NEW ELEMENT	FORMERLY	RATIONALE
WCti Wti	WC3ti W3ti	Warranty costs are applicable only at level 3.
TF_t	TF	Annual values provide ready identification of warranty period.
RTKRkti	RTDRti RTIRti RTORti	Single Mnemonic to replace 3. K implies "At a Maintenance Level" k defines specific level.
NRTSki	NRTSOi NRTIIi	Single mnemonic replaces multiple mnemonics. k defines specific maintenance level
RTOKki	RTOKD RTOKI	
PLYk	PLVD PLVI	
MTTRki	MTTRDi MTTRIi MTTROi	
DLRk	DLRD DLRO DLRI	
DMkti	DM3ti DM2ti	
OLkti	OL3ti OL2ti OL1ti	
OLRk	LORD LORI LORO	
GAkti	GA3ti GA2ti GA1ti	
GARk	GARD GARI GARO	
Tkti	T3ti T2ti	

RSkti	RS3ti RS2ti	Single mnemonic replaces multiple mnemonics. k defines specific maintenance level
CONDki	CONDi COND2i	

301 Repair Item Data

Identifies a specific repair item and lists a number of parameters which are constant or maintenance level oriented. This card is one of a "package" of 4 cards (301 through 304) which completely (and uniquely) defines the repair item. The card contains a suffix number which relates it to the other seven cards in the package and is indented as an internal item identification number. Additional cards, which are not listed here, may be used to provide an additional 74 characters/card of item identification (e.g. Part Number, Stock Number, Circuit Symbol, etc.).

302 Repair Item Data

Identifies warranty costs, for up to 10 years, for the item identified on card 301 suffixed with the same suffix as this card 302.

303 Repair Item Data

Identifies production costs, for up to 10 years, for the item identified on card 301 suffixed with the same suffix as this card 303.

304 Repair Item Data

Identifies Mean Time Between Removals and Reliability Improvement Factors (Growth), as well as Mean-Times-To-Repair at each maintenance level (with Depot Repair Process Improvement Factors), for up to 10 years, for the item identified on card 301 suffixed with the same suffix as this card 304.

305 Constants

Identifies constant parameters not specifically oriented to individual repair items.

306. Program Year Data

Identifies yearly parameters not specifically oriented to individual repair items.

307 Maintenance Level Data

Identifies maintenance level parameters not oriented toward individual repair items.

COMPUTES	CC	DATA	SYMBOL	UNITS	VALUES
REPAIR	1- 3	Card Number	-	-	301
ITEM	4- 6	Card Suffix	-	-	000-999
DATA	7-21	Item Identification	*INOMj	-	Nomenclature
	22-26	Weight	Wi	lbs.	000.00-999.99
	27-28	Quantity/System	QPSi	#	00-99
	29-35	Material Cost/Repair (Depot)	MCPR3	$	00000.00-99999.99
	36-42	Material Cost/Repair (I Level)	MCPR2	$	00000.00-99999.99
	43-46	Not Repairable at I Level (rate)	NRTS2	%	000.0-100.0
	47-50	Not Repairable at O Level (rate)	NRTS1	%	000.0-100.0
	51-54	Condemnation at Depot (rate)	COND3	%	000.0-100.0
	55-58	Condemnation at I Level (rate)	COND2	%	000.0-100.0
	59-62	Retest OK at Depot (rate)	RTOK3	%	000.0-100.0
	63-66	Retest OK at I Level (rate)	RTOK2	%	000.0-100.0
	67	Where Removed	REMK	#	
REPAIR	1- 3	Card Number			302
ITEM	4- 6	Card Suffix			000-999
DATA	7-13	Warranty Costs (Year 1)	WC1	$	00000.00-99999.99
	14-20	↓	↓	↓	↓
	21-27				
	28-34				
	35-41				
	42-48				
	49-55				
	56-62				
	63-69				
	70-76	Warranty Costs (Year 10)	WC10	$	00000.00-99999.99

COMPUTES	CC	DATA	SYMBOL	UNITS	VALUES
REPAIR	1- 3	Card Number	-	-	303
ITEM	4- 6	Card Suffix	-	-	000-999
DATA	7-13	Production Costs (Year 1)	PC1	$	000000.00-999999.99
	14-20				
	21-27				
	28-34				
	35-41				
	42-48				
	49-55				
	56-62				
	63-69				
	70-76	Production Costs (Year 10)	PC10	$	00000.00-99999.99

COMPUTES	CC	DATA	SYMBOL	UNITS	VALUES
REPAIR	1- 3	Card Number	-	-	304
ITEM	4- 6	Card Suffix	-	-	000-999
DATA	7-11	Mean Time Between Removals	MTBRi	HOURS	00.000-99.999
	12-14	Reliability Improvement Factor (Year 1)	RIF1	#	1.00-9.99
	15-17				
	18-20				
	21-23				
	24-26				
	27-29				
	30-32				
	33-35				
	36-38				
	39-41	Reliability Improvement Factor (Year 10)	RIF10	#	1.00-9.99
	42-44	Mean Time To Repair (Depot)	MTTR3	HOURS	000-999
	45-47	Mean Time To Repair (I Level)	MTTR2	HOURS	000-999
	48-50	Mean Time to Repair (O Level)	MTTR1	HOURS	000-999
	51-53	Repair Process Improvement Factor (Year 1)	RPIF1	#	1.0-9.9
	54-56				
	57-59				
	60-62				
	63-65				
	66-68				
	69-71				
	72-74				
	75-77				
	78-80	Repair Process Improvement Factor (Year 10)	RPIF10	#	1.0-9.9

COMPUTES	CC	DATA	SYMBOL	UNITS	VALUES
CONSTANTS	1- 3	Card Number	-	-	305
	4	Quantity INS/Vehicle	QPV	#	1-9
	5- 8	Percent Overseas I Level Shops	POI	%	000.0-100.0
	9-12	Shipping Costs/lb. Overseas	SCO	$	00.00-99.99
	13-16	Shipping Costs/lb. CONUS	SCC	$	00.00-99.99
PROGRAM YEAR DATA	1- 3	Card Number	-	-	306
	4	Transition Factor	TF1	#	0-1
	5		TF2		
	6		TF3		
	7		TF4		
	8		TF5		
	9		TF6		
	10		TF7		
	11		TF8		
	12		TF9		
	13		TF10		
	14-16	Number of Inventory Vehicles	NV1	#	000-999
	17-19		NV2		
	20-22		NV3		
	23-25		NV4		
	26-28		NV5		
	29-31		NV6		
	32-34		NV7		
	35-37		NV8		
	38-40		NV9		
	41-43		NV10		
	44-46	Monthly System Operating Hours	SOH1	HOURS	000-744
	47-49		SOH2		
	50-52		SOH3		
	53-55		SOH4		
	56-58		SOH5		
	59-61		SOH6		
	62-64		SOH7		
	65-67		SOH8		
	58-70		SOH9		
	71-73		SOH10		

COMPUTES	CC	DATA	SYMBOL	UNITS	VALUES
MAINTEN-	1- 3	Card Number	-	-	307
ANCE	4- 6	Number of Depots	NRS3	#	000-999
LEVEL	7- 9	Number of I Level Shops	NRS2	#	000-999
DATA	10-12	Number of O Level Shops	NRS1	#	000-999
	13-16	Percent Labor Verification at Depot	PLV3	%	000.0-100.0
	17-20	Percent Labor Verification at I Level	PLV2	%	000.0-999.9
	21-25	Direct Labor Rate (Depot)	DLR3	$	000.00-999.99
	26-30	Direct Labor Rate (I Level)	DLR2	$	000.00-999.99
	31-35	Direct Labor Rate (O Level)	DLR1	$	000.00-999.99
	36-39	Overhead Labor Rate (Depot)	OLR3	$	00.00-99.99
	40-43	Overhead Labor Rate (I Level)	OLR2	$	00.00-99.99
	44-47	Overhead Labor Rate (O Level)	OLR1	$	00.00-99.99
	48-53	General Admin. Rate (Depot)	GAR3	$	0000.00-9999.99
	54-59	General Admin. Rate (I Level)	GAR2	$	0000.00-9999.99
	60-65	General Admin. Rate (O Level)	GAR1	$	0000.00-9999.99

RDT&E

Summary Equation

Redefine DE as:
Design Engineering Costs

DE

Redefine all elements which presently include (Required). The implication of this structure is that these elements while the others may not be.

TSH

Redefine DPC as:
Development Production Cost Per Unit of Primary Hardware.

TSS

Redefine to include a number of units involved in the test, determine a number of failures during a turn-around-time and a confidence level of spares availability.

TSER

Replace NTV in equation with NTH.

Redefine NTH as:
Number of Units of Primary Hardware Used for Testing During RDT&E.

Redefine COH as:
Cost Per Test Operating Hours (Including Cost of Data Reduction).

TNER

The equation adds "Training Units x Cost/Unit" and "Training Locations x Cost/Set". If it is intended that there be a one to one correspondence between "locations" and "sets", the equation should be so defined (e.g. Include a "Sets per Location (SPL) factor and define it as SPL=1).

TNP

Redefine MCM as:
Total Instructor Cost Per Month

Redefine MHG as:

Total Personnel (Less Instructor) Cost per Training Hour

ECP

The equation, as stated, implies that the cost for any ECP will be identical to the cost for any other ECP. The equation should consider

the summation of the costs of the individual ECP's or express all costs as average values.

SWR

PC is undefined but is believed to be:

Production Cost Per Unit of Prime Hardware.

The use of the proportionality factor (PROP 7) is unclear. Note that the alternate equation for TSR has the same basic format less the proportionality factor.

RPMG

The technology index here is unlikely to be identical to that used in CS and therefore, should be redefined.

ACQUISITION

Summary Equation

CFE and IMA should be re-named to prevent confusion with the standard abbreviations for Contractor Furnished Equipment and Intermediate Maintenance Activity.

SRAC

UC_q is defined as "~~Average~~ Unit Cost....". Since average is total/number, isn't total = SRAC? ([illegible] Cost/Unit)

CINST

Same comment regarding CI here as UC_q in SRAC.

TSEA

Is it correct to assume that all shops will be identically equipped since the number of systems supported may vary?

If the equation stands as published shouldn't $SEAMOD_k$ and $SEAPAR_k$ be defined as" .. at each shop at the kth level of maintenance."?

In any event, since TSEAk is defined on an "at each shop" basis shouldn't NSE_{kj} be defined in the same way? Likewise RSE_{kj} (and the elements of RSE_{kj}).

By definition, the standard report format shown is incorrect:

$TSEA_1$ = The Acquisition Cost of Support Equipment at Each Shop at the kth (k=1=Organizational) Level of Maintenance ≠ Cost of Organizational Level Support Equipment.

TDA

Since NTOD is defined as a multiple of CP(TDV +TDG) which is also the first term of the equation, would it not be logical to redefine NTOD as:

Cost of Non. T.O. Type Technical Data Expressed as a Percentage of the Cost of T.O. Type Technical Data.

The equation then becomes:

$$TDA = \left[CP(1 + NTOD) + TDIC \right] (TDV + TDG)$$

TNEA

Again, this equation assumes that the training equipment at any repair station will cost the same as any other repair station at the same maintenance level.

SPHA

There is a study currently underway at Collins to validate the computation of spares/dollar method employed here. There may be a later suggestion regarding this item.

SLRU (or SSRU)

Add to the definition of IL:

$IL = 1$ for Unique Inventory Locations

Rewrite the equation as the summation of "Types of Inventory Locations.

SCOND

Label the summation symbol.

TNA_k

As defined the instructor labor costs are constant (i.e. Independent of the number of courses to be given).

Rewrite the equation to include NC_k in the first term and the equation becomes:

$$TNA_k = (ICL_k)(NC_k) \left[(LRI_k)(NI_k) + (LRS_k)(NS_k) \right] + CP_k + CM_k$$

The definitions for labor rates and course length should include a common time element (hours, weeks, etc.).

CFE

The equation should be rewritten to eliminate referral to a standard abbreviation.

This equation also assumes that any station which requires Field Engineering Services will require the same number of man-months of services as any other station.

FACA

Redefines CFACA as:

$CFACA_j$ = The Cost of the jth New Facility

IMA

The equation should be rewritten to eliminate referral to a standard abbreviation.

O&M

General See Data Element Change Listing

OM_{3t}

Equation assumes that sub-costs at any depot are the same as at any other depot.

$RTDR_{ti}$

This equation is equal to

$(RTOR_{ti})(NRTSI_i)$

which may lead to a basic computation (e.g. $RTOR_{ti} = TR_{ti}$ where TR_{ti} is defined as Total Returns in the t^{th} for the i^{th} Item) for economy.

WC_{3ti}

Redefine as WC_{ti} since Warranty Costs are only applicable at the depot.

GA_{3ti}

TF is not required since when TF is zero the second factor $(DL_{3ti} + DM_{3ti} + OL3ti)$ will also be zero. This thinking implies that the multiple application of TF is not economical. Rather, in the programming if TF = 0 the computation should be limited to WC_{ti} and for TF = 0 the computation of WG_{ti} is aborted.

OM_{2ti}

This equation also assumes that sub-costs at any I level shop are identical to those at any other I level shop.

$RTIR_{ti}$

See comment on $RIDR_{ti}$.

$$RTIR_{ti} = (TR_{ti})(NRTSO_i)$$

OM_{1ti}

Again, the assumption is made that sub-costs at any O level shop are identical to those at any other O level shop.

Inherent in the life cycle costs are certain recurrent costs which do not appear in any sub-model:

Inventory Item Management
Technical Data Management
Replacement Spares Costs

APPENDIX B

ATTENDANCE LIST

LCC SEMINAR

FEBRUARY, 1975

Attendees	Company
James H. Taylor	Honeywell, Inc.
Luther Reitmeyer	Honeywell, Inc.
Freda Kurtz	AFAL/RWA-3
Paul Palatt	IDA
Russ Stauffer	Dynamics Research Corp.
Frank Merlino	Northrop
Bob Adel	Northrop
Don DeBurkarte	Collins
Keith Gibson	Autonetics
Peter Palmer	C. S. Draper Lab
Bill Colcord	Lear Siegler, Inc.
Bob Rodriguez	Litton
Bob Beech	LTV
Bill Laird	NAVAIREWORKFAC/3341
Gene Smith	Instr. Div. MacDill AFB
Col. Harry Brewer	Chief, Maint. 1st Tact Wing MacDill AFB
Lt. Col. James Turner	Chief of Supply 1st Tact Wing MacDill AFB
Harry Putt Ray Hoopes Russ Buyse Jim Perry Jerry Ransdell Roger Spencer	Honeywell, Inc.
Frank Avalar	Smith Industries Clearwater, Florida

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These proceedings describe the activities of the sixth quarterly meeting of the Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems held 25 - 27 February 1975 in St. Petersburg, Florida. The proceedings contain the texts and slides (where available) of the invited papers and the results of sub-group meetings on creation of an LCC Task Group descriptive paper and preparation of input/output specifications and finalization of variable names for the LCC model under development.

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